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THE EFFECTS OF KINESIOLOGY TAPE ON PAIN AND RANGE OF MOTION FOR
INDIVIDUALS WITH SHOULDER PAIN

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THE EFFECTS OF KINESIOLOGY TAPE ON PAIN AND RANGE OF MOTION FOR
INDIVIDUALS WITH SHOULDER PAIN

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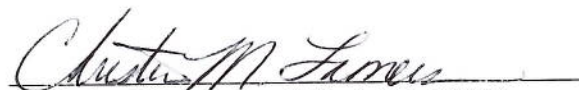
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ABSTRACT

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The purpose of this study was to determine the immediate and short term effects of Rocktape (RT) on shoulder pain and range of motion (ROM) for individuals with existing shoulder pain. Twenty collegiate students with existing shoulder pain participated in two functional upper body exercises (push-ups, throwing) for 6 separate sessions. The independent variables included taping conditions (bare, treatment, and sham) and time (immediate and 48 hours post taping). Shoulder pain, stability, and comfort were subjectively measured using Likert scales. Maximum shoulder abduction (AB) and external rotation (ER) were measured using 3D motion analysis during 25 maximal effort throwing motions with a 2-lb medicine ball at a stationary target. These values were acquired in the early to late cocking throwing phase. All tests were performed without, immediately after taping and 48 hours post taping for both taping conditions. Significant values were found when comparing the push-up and throwing exercises in regards to pain, stability, and comfort in all 3 conditions. Results showed no significant changes between the treatment and sham taping. These outcomes revealed that RT had no effect on shoulder pain and ROM.

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INTRODUCTION

Many sports injuries originate from or create a fault in the biomechanics of the body in motion as it pertains to specific athletic movements. Generally, overhead athletes are predisposed to chronic shoulder injuries and pain. According to the NCAA, from 1998-2004, 45% of all time lost from baseball and 33% of all time lost from softball because of injury was attributed to the upper extremity (Hibberd, Oyama, Tatman, & Myers, 2014). Shoulder injuries are frequently related to limitations in functional movement and/or abnormalities in shoulder posture. These deficits often lead to increased capsular tightness and decreased shoulder motion (Laughlin et al., 2014). Proper functioning of key musculoskeletal structures are therefore imperative for optimizing performance without inducing injuries. Some evidence shows that proper functional movement can increase the shoulder's subacromial space, thereby alleviating pressure and tightness in the area (Mihata et al., 2014).

There are a plethora of treatment modalities and methods for treating chronic shoulder injuries including ultrasound, electric stimulation, and rehabilitation exercises (Kaya, Zinnuroglu, & Tugcu, 2011). Among these common treatment options, therapeutic taping including Kinesiology Tape (KT) has gained popularity in the last few decades. KT is an elastic tape invented in the 1970's by Dr. Kenzo Kase to mimic the qualities of the human skin (Firth, Dingley, Davies, Lewis, & Alexander, 2010). KT has been proposed to help decrease the symptoms associated with shoulder injuries. Due to the fact that KT has grown in popularity since the 2008 Beijing Olympics, it is vital to

have an understanding of the research behind the effects of this product (O'Sullivan & Bird, 2011). However, the amount of research addressing these effects on shoulder injuries is limited.

There are various brands of KT, including Kinesio[®] Tape, KT Tape[®], K-active[®] Tape, and Rocktape[®]. One specific brand of KT that has been growing in popularity among healthcare providers is Rocktape[®] (RT). RT was created in 2008 by a physical therapist with the intent of making a more durable and non-restricting adhesive tape for the active population. RT is made up of 97% organic cotton and 3% nylon, and is also latex and zinc free. The ability for the tape to stretch up to 180% the original length results in full range of motion without restrictions according to the manufacturer. RT is water resistant and its durability allows it to be worn during intensive activity, in the shower, and in the pool without having to be replaced. These properties are claimed to ensure the continued application and therapeutic effects lasting up to 3 to 5 days according to the manufacturer. However, to our knowledge, there are no published clinical trials that measure the effects of RT.

There are multiple proposed benefits of using KT including: soft tissue healing, anatomical structural support, and decreased myofascial tightness (Thelen, Dauber, & Stoneman, 2008; Van Herzeele, Van Cingel, Maenhout, De Mey, & Cools, 2013). Additional effects include: muscle recruitment, muscle inhibition, enhanced lymphatic drainage, increased circulation, improved proprioception, and postural correction (Slupik, Dwornik, Bialoszewski, & Zych, 2007; Vercelli et al., 2012). These possible benefits are known to be dependent upon the amount of stretch applied to the tape. Research has shown that through these mechanisms, KT may decrease pain and increase range of

motion (ROM). According to recent research, KT provides structural support and increases muscle recruitment to assist this process (Van Herzeele et al., 2013). By assisting the movements in the shoulder with the use of KT, pain may be reduced and ROM may increase. A combination of these effects may help lead to greater pain free movement and therefore increased performance among the athletic population. These changes may help to reduce short term shoulder pain specifically for overhead athletes. On the contrary, a significant amount of research has found no change in symptoms with the use of KT (Firth et al., 2010; González-Iglesias, Fernández-De-Las-Peñas, Cleland, Huijbregts, & Gutiérrez-Vega, 2009; Merino-Marban, Mayorga-Vega, & Fernandez-Rodríguez, 2012). Specifically, the amount of research addressing the effects of KT on improving function and ROM in shoulder injuries is limited. A better understanding of the therapeutic effects of KT on factors such as pain, function, and performance will help clinicians determine if KT is a viable treatment option for individuals with shoulder injuries.

There is research that supports and negates the use of KT on improving pain and ROM specifically in the shoulder. However, specific research on shoulder pain and ROM using 3D analysis software with complex functional movement has yet to be tested. The purpose of this study was to compare the immediate and short term effects of a therapeutic RT application on pain, overall stability, overall comfort, and ROM in subjects with existing shoulder pain through functional upper body exercises.

METHODS

Subjects

A total of 20 collegiate students (9 female, 11 male; average age 21 ± 1.4 years; average height 178.69 ± 9.7 cm; average weight 81.8 ± 15.6 kg) with shoulder pain participated in this study. Inclusion criteria included (1) at least 2 months of self-reported shoulder pain on the dominant arm, and (2) a self-reported score of at least 4/10 on a standard 0-10 numerical pain rating scale (NPRS) with activity or at least 2 out of 5 positive tests for common shoulder injury. Testing was conducted by the primary investigator (Certified Athletic Trainer) and by two undergraduate athletic training students. These clinical evaluation tests included: Empty can, Full can, O'Brien's, Speeds, and Neer sign. The Empty can test and Neer sign were both used for inclusion criterion in previous research (Hsu et al., 2009). Kaya et al. (2011) also used Empty can test for inclusion criterion. All of these tests are performed primarily for diagnosing impingement, labrum tears, biceps tendinitis, and overall general shoulder pain according to Starkey, Brown, and Ryan, (2010). As the final part of the screening, each subject was asked to perform one set of 5 standard push-ups or 5 modified push-ups (from the knees). If the subject was not able to perform either style of push-ups, he/she was excluded from the study. Informed written consent was obtained from all subjects before enrollment, including the protection of all rights in accordance with the Institutional Review Board of the University of Wisconsin-La Crosse.

Taping Techniques

Taping procedures were applied by the primary author, certified in fascial movement taping (FMT) for RT and three co-investigators with previous experience applying RT on the shoulder. All subjects received both taping conditions (treatment, sham) in a randomly assigned order. Standard 2-inch RT was used for both taping conditions. The treatment tape application consisted of the standard shoulder taping technique recommended by RT and included three 2-inch strips (Figure 1). This application was recommended for general shoulder pain and is not specific to a particular injury. The tape was applied with the subject on a self-stretch (Thelen et al., 2008). The subject was first instructed to stand with their shoulders rolled anteriorly in protraction. The first strip was applied from the deltoid tuberosity of the humerus to the acromioclavicular (AC) joint, following the path of the posterior shoulder. This was applied with tape-off tension, which means that the tape was applied directly to the skin as it comes off the paper without stretching the tape. Tape-off tension with KT provides approximately 15-25% stretch due to the natural elastic properties of the tape (Thelen et al., 2008). The subject was then instructed to lift their shoulders up towards their ears and then bring them backward as if standing in perfect posture. From this position, the second strip was applied from the deltoid tuberosity to the AC joint following the path of the anterior shoulder. This strip was also applied with tape-off tension. While remaining in this position, the third and final strip known as the decompression strip was placed directly over the subject's location of most pain with approximately 50% tape stretch and with tape-off tension on both ends. This was applied in the horizontal direction, perpendicular to the direction of the muscle fibers. Due to the fact that the tape sticks

better to the skin than to tape, the beginning and end points of each strip were slightly staggered to allow for better tape adherence to the skin.



Figure 1. Treatment tape



Figure 2. Sham tape

The sham tape application consisted of two 2-inch strips of RT (Figure 2). For this taping procedure, the subject stood in a neutral or normal position and used their non-dominant arm to hold the wrist of their dominant arm at their navel, while relaxing their dominant shoulder. The first strip was cut down the middle, leaving a 2-inch base. The base was applied from the lateral epicondyle with the anterior strip extending to the coracoid process, and the posterior strip to the acromion with tape-off tension. The second strip was applied horizontally slightly inferior to the deltoid tuberosity with tape-

off tension and extended approximately 1-inch on either side of the first strip to allow to optimal adherence to the skin.

The purpose of including a sham tape was to create a similar looking application with the same product, while producing no intended treatment effect. Therefore, the sham technique was designed by the authors to be very different in regards to the subject's posture, tape location, and tape tension. The variations in methods in regards to the sham application included a relaxed posture, modified taping location distal to the common taping locations, and included only tape-off tension for the decompression strip. Subjects were never informed that there was a treatment and sham tape. It was assumed that subjects were blinded into thinking that two recommended taping techniques were being studied. When subjects asked why two different taping techniques were being studied, the authors responded by simply saying that two separate tape techniques for the shoulder were being compared.

Procedures

There were 4 variables being measured in the dominant shoulder including: pain, stability, comfort, and ROM. Surveys were utilized to subjectively measure pain on a standard 11 point NPRS with a score of 0 indicating no pain and a score of 10 indicating the worst pain possible. Pain measurements were taken before and after each exercise task for all taping conditions. At the beginning of each testing session, an additional question was asked specifying overall pain level for the previous 48 hours. Overall stability and overall comfort were loosely defined and left up to the subject's interpretation without specific detail into the definitions of stability and comfort. These measurements were recorded after each exercise with an 11 point numerical scale. A

score of 0 indicated extremely unstable or uncomfortable, and a score of 10 indicated extremely stable or extremely comfortable. Maximum shoulder abduction (AB) and external rotation (ER) motions were measured using Vicon Nexus (Vicon, Inc., Centennial, CO) and The Motion Monitor (Innovative Sports, Inc., Chicago, IL) 3D analysis software. ROM measurements were taken in the early to late cocking phase of the throwing exercise. A total of 22 reflective markers were placed on the upper body (Figures 3 and 4). Anterior marker placement included: jugular notch, xiphoid process, acromioclavicular joint (R,L), medial epicondyle (R,L), lateral epicondyle (R,L), ulnar head (R,L), styloid process of radius (R,L), proximal 1/3 humerus (R), proximal 1/3 radius (R), distal 1/3 humerus (L), distal 1/3 radius (L). Posterior marker placement included: C7, T8, superior angle of scapula (R,L), inferior angle of scapula (R,L)



Figure 3. Anterior marker placement



Figure 4. Posterior marker placement

Subjects completed a survey at the beginning of each session to measure current pain level and a separate question assessing pain level over the past 48 hours. For baseline measurements, no tape was applied. Reflective markers were placed on the subject and the subject was then calibrated into the computer software. The first exercise consisted of performing as many pushups as possible in 30 seconds. Subjects that completed the 5 standard push-ups during the screening were instructed to perform regular push-ups, while those who performed modified push-ups were instructed to perform modified push-ups. Hand placement for standard shoulder width push-up position was determined using the subjects total shoulder width (cm) from one shoulder to the other (Sorace 2012). This distance was marked out using tape on the floor and the subject placed the middle fingers of each hand on those pieces of tape. This was consistent for subjects performing standard and modified push-ups. Feet or knee width, depending on predetermined push-up technique, was approximately equal to hip width. Subjects were required to drop down far enough to touch their chest to the medicine ball

located 4-inches off the ground and then fully extend their arms at the top to ensure a full push-up movement. After performing this first task, subjects immediately took surveys to report their pain, stability, and comfort levels during the push-up exercise.

After approximately 1 minute, subjects began the second and final exercise. This exercise consisted of 25 total maximum speed overhead throws with a 2-lb medicine ball at a padded stationary target (Figure 5). The target was positioned 14-feet away and approximately 2.5-feet off the ground. The subject threw 3 medicine balls at the target to help become familiar with the exercise before testing began. Subjects were instructed to throw each ball at maximum speed with proper overhand throwing technique. Throwing speed and accuracy were not measured. They were also asked to throw consecutively without feeling rushed to prevent poor throwing form. The balls that had been thrown were gathered and returned to the subject to allow for 25 consecutive throws without any waiting period. AB and ER ROM were recorded during the first 5 throws (1-5) and the last 5 throws (21-25). After the exercise was complete, the subject immediately answered the same survey questions that were asked after the push-up exercise including pain, stability, and comfort related to the throwing exercise. Subjects were instructed to be careful when drying off in the shower and when changing clothes so that they would not accidentally peel the tape off. Additionally, if the tape were to slightly roll up on the ends, subjects were given the freedom to trim the tape. All subjects were asked to maintain their current levels of fitness.

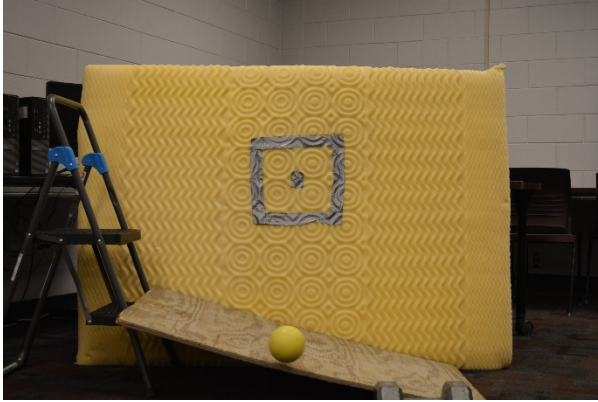


Figure 5. Stationary throwing target

A total of 6 sessions on 6 separate days constituted participation in this study. After the initial baseline testing without tape, each subject had one week to come in for their 2nd session. The 2nd session consisted of either the treatment or sham tape application through randomization. Subjects answered the current and past 48 hour pain surveys before being taped. After being taped, the subjects waited 10 minutes to allow for proper tape adherence before exercising to avoid compromising the effectiveness of the tape due to sweating. After 10 minutes, the subject completed the design protocol as previously described. Approximately 48 hours later, subjects returned and performed their 3rd session with the same tape on. This 48 hour period was designed to test and compare the effectiveness of KT over a two day period compared to 10 minutes post taping. After completing session 3, the tape was removed, and there was a minimum of one week wash-out period to help reduce the effects of the first taping condition on the subjects overall shoulder symptoms or function. After this one week period, subjects returned for session 4, which was another baseline session test without tape. The following week, sessions 5 and 6 were completed approximately 48 hours apart with the other tape condition.

Statistical Analysis

The independent variables included the taping conditions (treatment, sham), exercise (push-up, throwing), and time (sessions 1-6). The dependent variables were current pain, pain within 48 hours, stability, comfort, shoulder ER, and shoulder AB. Pain values consisted of the changes from the pre-activity level to after the respective exercise for each day. Because stability and control were being compared between two taping conditions, the raw scores were used. For pain, a 2 (taping conditions) x 3 (time) x 2 (exercise) all-within repeated measures analysis of variance (ANOVA) was performed. For stability and comfort values after each exercise (push-up and throwing) for immediate and 48-hour post-application effects, separate 2 (taping conditions) x 2 (time) x 2 (exercise) all-within repeated measures ANOVAs were used. A paired samples t-test was used to compare pain in the 48 hours from sessions 2-3 to the pain in sessions 5-6. The average time between sessions 2-3 and 5-6 was 47 hours and 44 minutes with a standard deviation of 0.2 hours. All survey scores were accounted for, however there was a small portion of missing data from the ROM measurements due to improper saving of information by the investigators. These missing variables were replaced with the series mean. For AB and ER motions with the throwing exercise, differences in the ROM from the mean of the first five throws to the mean of the last five throws were used for analysis. For each ROM difference, separate 2 (taping condition) x 3 (time) all within repeated measures ANOVAs were used. In the event of statistically significant findings, a post-hoc pairwise comparison with Bonferroni adjustment was utilized. Results from the repeated measures ANOVA were regarded significant at $P < 0.05$. All statistics analyses were performed using SPSS, version 22.0 software (SPSS Inc, Chicago, IL).

RESULTS

There was a significant main effect of exercise with pain ($F_{1, 19}=43.75$, $P<0.001$). Throwing seemed to elicit more pain relative to the pre-exercise pain level, compared to push-ups. Mean values of pain with treatment and sham taping were not significantly different (Table 1). The time*exercise interaction for pain with throwing did not reach statistical significance, but had a trend towards statistical significance ($F_{2, 18}=3.26$, $P=0.062$). Paired samples T-test for pain within 48 hours with RT revealed insignificant changes ($T=0.408$, $P=0.688$). There was a significant main effect of exercise ($F_{1, 19}=9.48$, $P=0.006$) and tape*time*exercise interaction ($F_{1, 19}=5.67$, $P=0.028$) in regards to shoulder stability (Table 2). A post-hoc pairwise comparison with Bonferroni correction revealed no significant differences on stability among taping conditions, time, and exercises. There was a significant main effect of exercise ($F_{1, 19}=11.68$, $P=0.003$) in regards to shoulder comfort (Table 3). AB and ER results revealed no significant differences between taping conditions or compared to baseline (Table 4). A pairwise comparison with Bonferroni correction revealed that at the baseline (between sessions 1 and 4), the ER ROM change was significantly greater with the treatment tape condition, compared to the sham tape condition ($P=0.041$).

Table 1. Mean pain rating change from pre-exercise pain level

		Treatment	Sham
Base	PU	1.0 ± 1.0	1.15 ± 1.4
	TH	3.65 ± 1.8	3.65 ± 2.0
Day 1	PU	1.30 ± 1.9	1.40 ± 1.9
	TH	2.50 ± 2.5	3.45 ± 2.3
Day 2	PU	0.70 ± 1.5	1.60 ± 1.9
	TH	2.50 ± 1.7	3.00 ± 2.0

PU, push-up; TH, throwing

*Reached 0.05 level of significance

Table 2. Mean stability rating

		Treatment	Sham
Day 1	PU	7.1 ± 2.3	6.7 ± 1.9
	TH	6.0 ± 2.4	6.2 ± 2.6
Day 2	PU	6.9 ± 2.6	7.3 ± 1.7
	TH	6.3 ± 2.4	6.0 ± 2.2

PU, push-up; TH, throwing

*Reached 0.05 level of significance

Table 3. Mean comfort rating

		Treatment	Sham
Day 1	PU	6.7 ± 2.4	6.1 ± 2.4
	TH	5.5 ± 2.4	5.3 ± 2.8
Day 2	PU	7.0 ± 2.5	6.5 ± 2.4
	TH	5.7 ± 2.5	5.2 ± 2.7

PU, push-up; TH, throwing

*Reached 0.05 level of significance

Table 4. Mean shoulder throwing ROM difference (degrees) (last 5 - first 5 throws)

		Treatment	Sham
Base	ABD	2.0 ± 6.3	-0.3 ± 6.4
	ER	1.3 ± 11.4	-8.4 ± 16.2
Day 1	ABD	0.8 ± 9.3	2.0 ± 7.6
	ER	-4.0 ± 17.2	-7.0 ± 11.9
Day 2	ABD	1.5 ± 6.1	0.0 ± 6.2
	ER	-1.6 ± 19.4	1.4 ± 9.4

ABD, abduction; ER, external rotation

*Reached 0.05 level of significance

DISCUSSION

The purpose of this study was to compare the immediate and short term (48-hour) effects of a therapeutic RT application on pain, overall stability, overall comfort, and shoulder ROM in subjects with existing shoulder pain through functional upper body exercises. Our results showed no significant differences between taping and baseline, or between the two taping conditions (treatment or sham). Additionally, this study did not yield any shoulder ROM differences from the first five to the last five repetitions during the throwing task, regardless of the taping condition.

Our study was unique in that we measured levels of pain, stability, and comfort before and after tape application, across 48 hours for both taping conditions, and between two different functional exercises. Significant differences in pain, stability, and comfort were found between the throwing and push-up exercises with throwing eliciting more pain, and less stability and comfort. There was also a significant Tape*Time*Exercise interaction for stability, which we assume may be primarily attributed by the significant main effect of exercise. Overall, the throwing exercise aggravated the subject's existing shoulder symptoms more than the push-up exercise, which was expected due to the greater duration and intensity of the task after being somewhat fatigued from performing the push-up task.

Pain

Previous research has reported benefits of KT in regards to pain (Hwang-Bo, Lee, & Kim, 2013; Kalichman, Vered, & Volchek, 2010; Kaya et al., 2011). While these aforementioned studies have contrasting results compared to our study which utilized RT;

our study also revealed somewhat consistent results with some previous research which utilized a different type of KT (Firth et al., 2010; Fu et al., 2008). None of the pain scales in our study exceeded the level of clinical importance of a 2-point reduction on the 11 point NPRS as used in previous research (González-Iglesias et al., 2009; Thelen et al., 2008.). The possible reason for our pain results not reaching statistical significance may be that the participants had a relatively low amount of pain throughout the study. Therefore, we may have not seen the significant reduction in pain with either tape application techniques, which is later discussed as a possible study limitation.

The lack of significant changes in pain after the exercise tasks may have been attributed to multiple factors such as: low pain levels at baseline, non-specific injuries, and simply no significant benefit of using KT. Pain was not significantly reduced with taping, which has been attributed to decreasing the fear of movement (González-Iglesias et al., 2009). Their study included subjects with acute whiplash, which usually includes a greater fear of movement in nature, and therefore may have had more room for improvement, whereas the majority of subjects in this study were experiencing mild symptoms of injury. However, it is possible that the treatment in our study was simply not effective in pain reduction. Pain was not significantly reduced after wearing KT for 48 hours. This suggests that KT may not have played a substantial role in recovery over a two day period.

Stability and Comfort

There seem to be no significant effects of the taping techniques on the differences in perception of overall stability and overall comfort across the exercises. Perhaps the reason for the unchanging stability results were due to the elastic properties of RT, which

may have only played a minimal role in adding stability. To our knowledge, this was the first study to measure the effects of RT on stability with injured subjects. Findings by Aktas and Baltaci (2011) revealed that KT and/or bracing improved lower extremity hop distance on healthy subjects. It was theorized by the authors that this may be due to an increase in stability. Our study did not measure performance such as throwing velocity; therefore, it cannot be stated if the use of RT improved performance. Similar to our pain and stability findings, the differences in comfort across exercises, time, and taping conditions did not reach a clinical importance of a 2-point reduction on an 11 point scale (Merino-Marban et al., 2012).

To our knowledge, this was the first study to measure the effects of RT on comfort with functional movement on injured subjects. Similar insignificant results regarding comfort levels when wearing KT compared to bare skin baseline were found by Merino-Marban et al. (2012). Perhaps KT may not provide adequate comfort or stability through aggressive functional movements. One possible explanation for this may be due to the greater extensibility of KT compared to other traditional options such as bracing or athletic taping. A suggestion for future research would be to include performance measures and also to compare stability between RT and traditional bracing.

ROM

This study has shown that RT had no significant effect on functional ROM on our particular subject population, unlike other studies that found significant changes in ROM with KT (González-Iglesias et al., 2009; Hwang-Bo et al., 2013; Yoshida & Kahanov, 2007). The lack of significant ROM differences may be attributed to the type of ROM being measured. Most studies use simple single plane movement, while this study

incorporated functional multi-planar movements. Performing functional movements with KT using 3D analysis has not been done for the shoulder prior to this study. These results may suggest a more specific representation of KT's effects on functional ROM in the shoulder. It may be important to consider the variety of injuries among subjects. The ROM deficits may vary based on the type of injury, and therefore testing AB and ER with a throwing exercise may not have accurately represented the motion that was restricted for all subjects.

Physiological Effects

There may be beneficial physiological effects of RT that were not measured in this particular study such as reducing muscle fatigue and promoting blood flow for faster recovery. More specifically, KT may enhance activity of the lymphatic system and endogenous analgesic mechanisms as well as improving microcirculation (Slupik et al., 2007). The most commonly associated theory of pain reduction with KT is the gate control theory, in which the tape is thought to stimulate neuromuscular pathways through increased afferent feedback (Kaya et al., 2011). This increase in afferent stimulus to large-diameter nerve fibers can serve to mask the input received from the small-diameter nerve fibers conducting nociception (Thelen et al., 2008). Even though a proper screening was performed, our sample population displayed a small amount of pain throughout the study. A relatively low amount of pain may not have contributed to a large fluctuation in ROM from the beginning to the end of the throwing task, regardless of the taping conditions. It would be useful to include those with a higher amount of pain in the future studies.

Another potential benefit of KT seen in research is an increase in EMG activity. This is often attributed to an increased proprioceptive stimulus and therefore, an increase in motor unit recruitment (Slupik et al., 2007). One study suggests that the changes in the firing patterns of the rotator cuff muscles may contribute to the increased acromiohumeral distance, via application of KT (Luque-Suarez, Navarro-Ledesma, Petocz, Hancock, & Hush, 2013). However, this theory of the increased motor unit recruitment with KT is not supported in other research (Vercelli et al., 2012). Also, considerable thought must also be given to the possibility of a placebo effect or simply a cutaneous stimulus effect that does not play a major physiological role. A placebo effect has been suggested by some as the only effect (Thelen et al., 2008). The physiological mechanisms of KT that are said to be effective may just be speculation. These theories regarding physiological effects were not measured in this study and therefore no conclusions can be drawn as to the physiological effects of RT. Future research utilizing a combination of physiological and functional effects of KT would be beneficial for further investigation.

Limitations

One of the limitations of this study was subjects with low initial baseline pain levels (average=1.3 ±1.5). This may have given minimal room for substantial change with RT application. All subjects fit the inclusion criteria for pain (at least 4/10), however, many of the subjects were not experiencing that level of pain throughout their participation in this study. Perhaps if the pain criteria would have been stricter, changes in pain may have been seen. Another limitation was that the injuries were not specified. The application procedures of KT are often dependent upon the specific condition of an

individual. However, amongst various injuries and conditions, all subjects in this study received the same RT applications. Including a specific shoulder injury such as shoulder impingement syndrome as researched by Kaya et al. (2011) may have provided more consistent data. Another limitation is the uncontrolled activities of the subjects outside of the testing lab. Through the five-week testing period, there are many factors outside of testing that were not controllable. This period may have allowed some subjects to feel better simply due to increased healing time from previous injury. Shortening this period may have resulted in different results. Although the sample size of 20 subjects was deemed sufficient for our cross-over study, more subjects would have increased the methodological quality of the study. We aimed to compare the effects of two different taping techniques on subject-oriented outcomes and shoulder ROM and therefore chose to implement a cross-over design. However, a randomized clinical or control trial may have yielded different results.

KT is meant to be used in combination with other physical therapy, rehabilitation, or exercise (Hsu et al., 2009). Future research should look into the immediate, short term, and long term effects of KT on shoulder pain and ROM with functional movement in combination with rehabilitation or exercise programs such as in existing research by Kaya et al. (2011). Additionally, future research should examine the effects of a therapeutic KT application and sham application in regards to pain and ROM on a specific injury with more substantial deficits. Measuring ball speed with the throwing exercise may give more insight into the usefulness of KT during performance and possible muscular fatigue. Our subject sample of 9 females and 11 males enrolled in undergraduate school probably has moderate validity for the average collegiate

population. However, a sample with more diverse age groups and activity levels may yield more clinical applications.

CONCLUSIONS

When applied to collegiate students with existing non-specific shoulder pain, RT did not have a significant immediate or 48 hours post-application effect in regards to shoulder pain, overall stability, overall comfort, or ROM with functional exercises. Future studies should examine if RT assists in therapeutic benefits for injured subjects when combined with physical therapy.

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APPENDIX A
INFORMED CONSENT

Informed Consent

Title of Study: The Effects of Kinesiology Tape on Pain and Range of Motion for Individuals with Shoulder Pain

Researcher: Reggie Ronning Exercise Sport Science Graduate Program, University of Wisconsin- La Crosse

PLEASE READ THE FOLLOWING INFORMATION CAEFULLY TO FULLY UNDERSTAND THE RESEARCH STUDY. YOUR SIGNIATURE CONFIRMS THAT WE HAVE INFORMED YOU OF THE PURPOSE OF THE STUDY. YOUR DECISION TO PARTICIPATE IS VOLUNTARY AND BY SIGNING YOU UNDERSTAND THE RISKS AND POTENTIAL BENEFITS ASSOCIATED.

Why is this research study being done?

This study is being conducted to:

- Measure the effects of Rocktape (RT) as a treatment option for shoulder pain.
- Determine the correlation between shoulder range of motion and shoulder pain.
- Determine and contrast the effects of two RT techniques for the shoulder.

How many people will take part in the study?

Approximately 20-25 male and female college/university students who have experienced two or more months of shoulder pain. Additionally, subjects must report a score of at least 4/10 on standard pain scale or have at least two of five positive shoulder special tests with pain. Participants must be collegiate students enrolled at the University of Wisconsin- La Crosse, Viterbo University, or other surrounding colleges. Participants who do not fit these criteria will not be included in the study.

Why are you being asked to participate in this study?

You are being asked to participate because you are enrolled in college and have experienced shoulder pain for at least two months and have reported a score of at least 4/10 on a standard pain scale or have at least two of five positive shoulder special tests with pain.

What will happen in this study?

In this study, you will be tested in a variety of ways. You will be asked to perform 20 consecutive maximal speed overhand throws with a 2 lb medicine ball and as many pushups as you can in 30 seconds. The throwing measurements will be recorded with a 3D motion analysis system to measure shoulder range of motion throughout entire movement. You will be asked to

describe your level of pain each session on a 1-10 scale (1=slight pain, 10=extreme pain). It is expected that you will not alter training or exercise habits throughout the duration of this study.

Muscular endurance and resistance to fatigue will be associated with these exercises. Testing will take place at the University of Wisconsin- La Crosse Exercise and Sport Biomechanics Laboratory located in Mitchell Hall. Testing will be conducted by the primary researcher Reggie Ronning (ATC, certified in RT) with the assistance of advanced undergraduate athletic training students in the University of Wisconsin- La Crosse Athletic Training Program who have had experience with RT.

How long will the research study last?

From start to finish, this study will span over a period of approximately 3 weeks and 6 separate sessions. Each session will last about 30 minutes with the exception of the session 1 lasting about 1 hour. Sessions 2 and 3 will be conducted approximately 48 hours apart. The therapeutic effects of RT is expected to span over a period of 5 days without any decrease in effectiveness. This study will determine the efficacy of RT over a 48 hour period.

Are there reasons that I might leave the study early?

Your decision to participate in the study is completely voluntary. You may decide to stop participation at any point without penalty. If at any time the researcher finds that the testing is not in your best interest, the researcher will stop the testing.

What are the risks of the study?

The risks associated with this study are limited to the soreness, fatigue, and pain associated with shoulder exercises in individuals with shoulder pain. The adhesive materials used to attach markers for motion analysis and for tape application may result in minor skin irritation. This should only last a few hours after adhesive material is removed.

Are there benefits to taking part in the research study?

There are no anticipated benefits for the participants. However, information and results derived from the study will provide beneficial data to health care professionals in optimizing the most appropriate and effective care of treatment for people with shoulder pain. Reducing shoulder pain with the modality choice of RT may help relieve current signs and symptoms as well as prevent future re-injury.

Will there be any cost for participation in the study?

There will be no cost, however, transportation to and from the testing site is your responsibility.

What happens if I am injured while in this research study?

In the event that an injury occurs during the testing, automatic reimbursement is not provided by the Board of Regents of the University of Wisconsin System, and the University of Wisconsin- La Crosse, their officers, agents, and employees. The risks associated with this study run the minimal risk of injury and must be weighted in the decision to sign for consent to participate.

For information about policies, the conduct of the study, or the rights of research subjects, please contact the University of Wisconsin- La Crosse Institutional Review Board (IRB) for the Protection of Human Subjects (608-785-6892; irb@uwlax.edu). The IRB is a group of people who review the research protocol to protect the rights of research participants.

What are my rights by partaking in this study?

Taking part in this study does not take away any rights or benefits that you would experience by not taking part in this study. This study does not include any special privileges. If at any point you decide to withdraw from the study, there is no penalty. As a participant you will be told of the new findings or procedural changes that were found in this study should you choose.

What about confidentiality?

To ensure confidentiality, all data will be stored in a password protected personal computer. The information from the study will only be available to participants to see their own data. Outcomes may be published or represented as group averages, but will not include any personal information linked to identifying specific participant results. Participation in this study will remain confidential.

Who can answer my questions?

You may talk with the head researcher Reggie Ronning (320-766-1583; ronning.regg@uwlax.edu) and the faculty advisor Dr. Naoko Aminaka (608-785-8785; naminaka@uwlax.edu) at any time regarding this study.

I HAVE READ ALL INFORMATION ABOVE, ASKED QUESTIONS, RECEIVED ANSWERS CONCERNING QUESTIONS/COMMENTS, AND I WILLINGLY GIVE MY CONSENT TO PARTICIPATE IN THIS STUDY. UPON SIGNING THIS FORM, I WILL RECEIVE A COPY.

(Date)

(Signature of Individual Obtaining Consent)

(Print Name)

APPENDIX B
PRE-EXERCISE SURVEY

Pre-Exercise Survey

How much shoulder pain do you have at this moment?



Overall, how would you rate your shoulder pain in the last 48 hours?



APPENDIX C
POST-EXERCISE SURVEY

Post-Exercise Survey

During the push-up exercise:

How much shoulder pain did you have?



How stable did your shoulder feel?



How comfortable did your shoulder feel?



During the throwing exercise:

How much shoulder pain did you have?



How stable did your shoulder feel?



How comfortable did your shoulder feel?



APPENDIX D
REVIEW OF THE LITERATURE

Review of the Literature

Background

Shoulder injuries can inhibit activities of daily living and can contribute to decreased athletic performance. Many sports injuries originate from or create a fault in the kinematics of the body in motion as it pertains to specific athletic movements. Shoulder injuries are frequently related to limitations in functional movement and/or abnormalities in shoulder posture predisposing athletes to injury. These deficits often lead to increased capsular tightness and decreased shoulder motion (Laughlin, Fleisig, Scillia, Aune, Cain, & Dugas, 2014). Increased pressure and tightness in the shoulder with functional movement can be alleviated by increasing the shoulder's subacromial space (Mihata et al., 2014). Proper functioning of key musculoskeletal structures are therefore imperative for optimizing performance without inducing injuries. Generally, overhead athletes are more predisposed to chronic shoulder injuries and pain due to repeated stress on the shoulder. According to the NCAA, from 1998-2004, 45% of all time lost from baseball and 33% of all time lost from softball because of injury was attributed to the upper extremity (Hibberd, Oyama, Tatman, & Myers, 2014). In addition to increased pain, shoulder injuries can limit range of motion (ROM) for athletes that perform overhead movements such as in baseball, softball, volleyball, swimming, and tennis. These limiting factors typically lead to a negative effect on sports performance.

There are a plethora of treatment modalities and methods for treating chronic shoulder injuries including ultrasound, electric stimulation, and rehabilitation exercises (Kaya, Zinnuroglu, & Tugcu, 2011). Among these common treatment options, therapeutic taping including Kinesiology Tape (KT) has gained popularity in the last few decades. KT is an elastic tape invented in 1970's by Dr. Kenzo Kase to mimic the qualities of the human skin (Firth,

Dingley, Davies, Lewis, & Alexander, 2010). KT may help decrease the symptoms associated with shoulder injuries. Due to the fact that KT has grown in popularity since the 2008 Beijing Olympics, it is vital to have an understanding of the research behind the effects of this product (O'Sullivan & Bird, 2011). However, the amount of research addressing these effects on shoulder injuries is limited. Also, it is important to research the differences in the various popular brands of KT including: Kinesio® Tape, KT Tape®, K-active® Tape, and Rocktape®. A better understanding of these effects will help to determine if KT is a viable treatment option for individuals with shoulder injuries.

There are multiple proposed purposes to use KT including: soft tissue healing, anatomical structural support, and decreased myofascial tightness (Thelen, Dauber, & Stoneman, 2008; Van Herzele, Van Cingel, Maenhout, De Mey, & Cools, 2013). Additional proposed effects include: muscle recruitment, muscle inhibition, enhanced lymphatic drainage, increased circulation, improved proprioception, and postural correction (Slupik, Dwornik, Bialoszewski, & Zych, 2007; Vercelli et al., 2012). Research has suggested that through these effects, KT may decrease pain and increase ROM (Thelen et al., 2008). According to recent research, KT provides structural support and muscle recruitment to assist this process (Van Herzele et al., 2013). By assisting the movements in the shoulder with the use of KT, pain may be reduced and ROM may increase. A combination of these effects may help lead to greater pain free movement and therefore increased performance among the athletic population. These changes may help to reduce short term shoulder pain specifically for overhead athletes.

Existing research has addressed some of the potential benefits of KT regarding their indicated effects. However, there is a great need for additional research considering the limitations of current research. This literature review is necessary to tackle the limitations and

also to revisit the methods of existing literature for the purpose of advancing research on the topic of KT. The foundation behind conducting future research is based upon incorporating author's recommendations from published research and incorporating new forms of functional analysis techniques. This will help to further understand the effectiveness of using KT as a form of treatment for health care professionals in comparison to traditional forms of treatment and preventative care. This comprehensive review of literature will discuss the effects of KT on the following: 1) shoulder posture, kinematics and ROM, 2) pain reduction, and 3) functional performance, muscle excitability, and other related factors. In addition to the three main subtopics, a general discussion is included regarding other factors such as the tape's longevity, neural activation, comfort, and stability.

Shoulder posture, kinematics, and ROM

Prevalence of shoulder pain in someone's lifetime has been reported to range from 7-36% of the population, with rotator cuff pathology and shoulder impingement syndrome (SIS) among the most commonly diagnosed (Thelen et al., 2008). Relief from shoulder pain is often linked to certain physical changes. Three common contributing factors that are often associated with shoulder pain include abnormal muscle functioning, improper scapular kinematics, and decreased subacromial space. According to Hsu, Chen, Lin, Wang, and Shih (2008), scapular dysfunction can predispose athletes to micro trauma and chronic pain. The coordinated scapular movements are accomplished by the sophisticated neuromuscular controls of the muscles attaching to the scapula. The purpose of this study was to determine if a link exists between scapular kinematics, muscle strength, and KT in baseball players with existing shoulder pain. All subjects in this study had been diagnosed with SIS by having pain with at least two out of five tests for SIS including the empty can test, Hawkins sign, and Neer sign. Subjects participated in

three separate exercises including: three scaption movements with a 2 kg dumbbell, three 5 second isometric scaption holds at 125°, and three maximal isometric contractions in a prone position. Electromyography (EMG) activity was taken for the serratus anterior and lower trapezius muscles during these exercises. Scapular kinematics were recorded during these exercises using a 3D Liberty Electromagnetic Tracking System. KT was applied in two strips along the lower trapezius. All subjects performed the same protocol; however, one group received a placebo taping consisting of surgical tape instead of KT. Results showed that certain movements such as posterior tilt and internal rotation of the scapula were increased with KT alone. KT significantly increased muscle activation in both muscles tested for some positions, while not having an effect on others. Scapular kinematics were not consistently different between the therapeutic and placebo tape. The results from this study are helpful for further research by suggesting a potential increase in muscle activation with KT as well as benefits to scapular kinematics in overhead athletes.

Additional research into scapular kinematics was conducted by Van Herzeele et al. (2013). The purpose of this study was to investigate the effect of a specific KT method on scapular kinematics in healthy elite female handball players. All subjects received the same KT (K-active® tape) application. Taping included one strip from coracoid process to thoracic spine, which spanned over the upper trapezius. The purpose of this specific taping method was to assist with proper scapular anatomical position. Scapular position was measured using a 3D Fastrak device. More specific measurements included: scapular external rotation, scapular upward rotation, and scapular posterior tilt. Associated movements during testing included: abduction, flexion, and scaption at 5 separate elevation angles (0°, 30°, 60°, 90°, and 120°). Results showed a moderate to large effect (Cohen's $d > 0.7$) towards scapular posterior tilting for all 3 planes of

movement and all angles of elevation. Moderate increases were discovered for upward rotation at 3 separate positions of humeral abduction. Although not all data showed significant changes, this information suggests that KT causes positive changes in scapular motion, which may help in injury prevention and/or treatment. There is a need for these clinical findings to be applied to more functional sport specific movements, specifically for healthy and injured overhead athletes. The use of a sham tape would be useful in ruling out the placebo effect as seen in other research (Pelosin et al., 2013).

Decreased subacromial space or acromiohumeral distance (AHD) also leads to SIS. Luque-Suarez, Navarro-Ledesma, Petocz, Hancock, and Hush (2013) conducted research to determine if KT could increase the AHD. Healthy subjects were put into one of three groups. Groups 1 and 2 included the same KT taping technique (with the exception of the direction of the tape pull) while in maximal shoulder external rotation to place the shoulder on a stretch. Group 3 received a sham tape application with no pull on the tape and with the shoulder in a relaxed position. Using ultrasound measurements, AHD was recorded at 0° and 60° shoulder elevation immediately after tape application. Results showed significant improvements in ADH after KT, compared to sham. No significant differences were found in the direction the tape was pulled. These findings encourage the use of KT to increase AHD, which may prevent injury or reduce symptoms associated with SIS. Shoulder injury etiology is often linked to instability (Ujino, Eberman, Kahanov, Renner, & Demchak, 2013). KT can help to provide shoulder stability by modifying posture and/or mechanics. Additional research using this technique with a more functional movement approach would further help to determine the effects in an overhead sport setting where SIS is most prevalent. Significant long term effects up to one month have been seen using KT to improve shoulder posture. (Hwang-Bo, Lee, & Kim, 2013).

Improper shoulder kinematics as well as deficient ROM can cause and/or enhance pain associated with shoulder injuries. Recent research by Thelen et al. (2008) studied the effects of KT on shoulder pain and ROM. All subjects in the study complained of shoulder pain and also tested positive for the following clinical tests for shoulder pain: empty can and Hawkins Kennedy. Subjective complaints were also criteria for participation in this study. Subjects were separated into two groups (treatment and sham). The treatment group received therapeutic KT application (Kinesio® Tape). Specifically, three strips were applied to the supraspinatus, anterior deltoid, and posterior deltoid. As seen in other research, the subject was placed in a maximum self-stretch position (Pelosin et al., 2013). Approximately 50% stretch was applied to the tape while placing it on the posterior deltoid over the region of pain or tenderness. The sham KT was applied with no anticipated therapeutic effect by applying no stretch. Additionally, the second sham strip was placed below the middle deltoid insertion to minimize any potential benefit of the tape. To ensure blinding of the subjects, all subjects put on clothing to conceal the tape. Measures were taken for pain free ROM (using a goniometer) in shoulder flexion, abduction, and scaption. An 11 point numerical pain rating scale (NPRS) was used to assess pain intensity at the endpoint of pain-free active shoulder ROM. Measures were recorded for baseline, immediately after taping, three days post taping, and six days post taping. However, subjects were instructed to return to the clinic for testing 12 to 24 hours after removing the tape. Therefore, only the immediate tape application included testing with KT. Results showed that KT showed significant increases in ROM when limited by musculoskeletal shoulder pain for certain conditions. Although the treatment group showed a meaningful change in abduction ROM immediately after taping (at least 15 degrees increase), the results did not hold true on day three. This may suggest successful short term effects, but does not support the long term effects of KT. The sham

treatment had no impact, indicating a neutral treatment effect as desired. This study did not result in a change of clinical importance (at least 2 point reduction) in pain according to an 11 point NPRS for subjects with shoulder pain.

Current research has shown that KT can improve joint ROM (González-Iglesias, Fernández-De-Las-Peñas, Cleland, Huijbregts, & Gutiérrez-Vega, 2009; Kaya et al., 2011; Thelen et al., 2008; Yoshida & Kahanov, 2007). However, the effects of KT in comparison and/or combination with other treatment options may provide more useful insights. Stretching is one of the most traditional methods of improving ROM. Ujino et al. (2013) tested the effects of KT on shoulder internal rotation (IR) and external rotation (ER) on healthy individuals in contrast and combination with stretching. Subjects were assigned to one of 3 groups: KT only, stretching only, or KT and stretch. Testing took place on day 1 and day 4. Subjects with KT kept the tape on for the entire 3 day duration. Similarly, subjects in the stretch only or KT and stretch groups performed stretching for 3 days. Stretching protocol included a sleeper stretch, doorway stretch, and cross body stretch (3 times per day for 30 second holds) to increase shoulder IR and ER. Results showed the greatest improvement in ROM for the KT only group. Stretching was not found to have an effect on shoulder ROM, even when combined with KT. The reason may be due to a placebo effect, which was not addressed and would have added validity to the study. Another reason for this is possible unequal distribution of age and/or gender which was not specified in the procedures. This inconsistency suggests the need for further research for KT on shoulder ROM, specifically ER as it is often limited in injured overhead athletes in need of increased pain free shoulder ROM.

Due to the limited research on the effectiveness of KT among shoulder injuries, additional evidence for the effect of KT on movement at other parts of the body including trunk,

cervical, and lower extremity may be helpful. Findings from Yoshida and Kahanov (2007) help support the use of alternative treatments such as KT as a viable option to treat athletic injuries and improve ROM. The purpose of this study was to determine the effects of KT on lower trunk flexion, extension, and lateral flexion active ROM. Healthy subjects without previous history of back pain were selected. KT was applied along the back musculature parallel to the erector spinae muscle group with the subject on a forward flexion stretch. All subjects performed trunk flexion, trunk extension, and right lateral flexion with and without the application of KT. These three directions accurately represent what athletic trainers and physical therapists commonly focus on when attempting to gain ROM this region of the body, because it is commonly an area of limitation. There were no significant differences in trunk extension and right lateral trunk flexion for patients with KT. However, trunk flexion yielded significant results with the use of KT. One possible cause of increased trunk flexion with KT according to Yoshida and Kahanov (2007) is that the taped region may cause an increase of blood circulation positively affecting the muscle and myofascial functions. Another possible cause for these results is that KT stimulates cutaneous mechanoreceptors at the taping site. Although not all of the results were consistent with all directions tested, there was a significant increase in trunk flexion ROM.

Individuals are sometimes not able to normally function through daily activities if there are deficits in joint ROM. González-Iglesias et al. (2009) looked at the effects of KT on cervical ROM and pain for individuals with acute whiplash injury. Whiplash often leads to painful neck spasms which decreases pain free ROM. Subjects who were clinically diagnosed with whiplash were randomly assigned to one of two groups. Group 1 included KT (Kinesio® Tape) applied with tension for maximum therapeutic effects, while group 2 included the same KT applied without tension to mimic a sham application. Active cervical ROM was measured using a

cervical range of motion (CROM) device. CROM was measured at baseline, immediately after KT application, and 24 hours post KT application. Results showed a statistically significant difference using the therapeutic KT immediately and 24 hours post application compared to baseline in all cervical motions tested. According to the authors, the clinical effectiveness of KT for reducing pain and improving cervical ROM may be difficult to establish on individual patients, because the average expected change is less than the error attributed to repeated measurements. This suggests a need for further research in this topic. It was suggested by the authors that there may potentially be greater effects if observed over a longer period than 24 hours.

Further research into the effects of KT on ROM was conducted by Lumbroso, Ziv, Vered, and Kalichman (2013). This study focused on ROM in the lower body for healthy subjects. Measured movements included: passive straight leg raise (SLR), knee extension angle (KEA) test, and weight bearing ankle dorsiflexion. Application of KT (Kinesio® Tape) was applied to either the gastrocnemius or the hamstring, depending on the randomly assigned groups. KT on the hamstrings was applied with tension proximal to distal, whereas KT on the gastrocnemius was applied with tension from distal to proximal. Both groups participated in the same testing procedures. ROM measurements were taken at baseline, 15 minutes post application, and 48 hours post application. The results showed significant differences immediately in the gastrocnemius group for the SLR and dorsiflexion movements. After 48 hours, the same group experienced significant improvements in KEA. The hamstring group did not experience significant differences in any ranges of motion. These results show inconsistency in the timing of benefits from KT. Additionally, it suggests that certain muscle groups or certain application techniques may have greater benefits with KT than others. The distal to proximal

tension application may assist the muscle more than taping proximal to distal. This study did not include an alternative tape job, which does not rule out the possibility of a placebo effect. The authors suggested using a sham tape application and randomization of KT application order for future research.

In summary, these studies looking at shoulder posture, kinematics, and ROM provided some valuable insight into this topic. KT has the potential to modify incorrect shoulder posture (Luque-Suarez et al., 2013). Additionally, research has shown that KT can have a significant effect on improving shoulder and scapular kinematics (Van Herzeele et al., 2013). This may be helpful in both preventing and treating injuries. A common limiting factor for individuals with shoulder pain is a lack in ROM, specifically external rotation (Mihata et al., 2014). Although it was not consistent in all studies, KT has shown significant effects for improving ROM (Lumbroso et al., 2013). Research has suggested potential benefits of KT for improving shoulder posture, kinematics, and ROM. However, there are still mixed results regarding the efficacy of KT as a treatment option. Also, many studies only investigated the effects of KT immediately after application, or up to 24 hours after application. Since the suggested duration of continuous KT application can be up to 3 to 5 days, more studies should investigate the effects of KT on various outcomes beyond 24 hours of application.

Pain

SIS is the most common shoulder complaint in orthopedic clinics and the most frequent cause of shoulder pain in overhead athletes. (Hsu et al., 2008). Recent research by Kaya et al. (2011) discussed that the etiology of SIS may include: anatomic abnormalities, tension overload, ischemia, degeneration of the rotator cuff tendons, and shoulder kinematic abnormalities. Additionally, the pain associated with shoulder injuries may be exacerbated by inflammation in

the suprahumeral space, inhibition of the rotator cuff muscles, and altered kinematics. The purpose of the study by Kaya et al. (2011) was to compare the short term effects of KT on reducing pain in subjects with shoulder injuries, as compared to commonly used modalities. Individuals (ages 18-70) presenting with SIS were enrolled in the study. A total of 30 subjects were placed into the physical therapy (PT) group, and another 30 patients were enrolled into the KT group. The KT group received KT located on three muscles (supraspinatus, deltoid, and teres minor). Through the 2-week testing period, KT was applied three separate times. The PT group daily received PT modalities during a 2-week duration including: ultrasound (5 min, 1 MHz, and 1 W/cm²), hot pack (20 min), and electrical nerve stimulation (20 min). A home exercise program (HEP) was also given to both groups. This HEP consisted of isometric strengthening exercises, range of motion, stretching, and relaxation of the trapezius twice daily. All subjects were asked to go about normal daily activities with the addition of the HEP. The Disability of Arm, Shoulder, and Hand (DASH) scale (to assess function) was evaluated only before and after the 2-week treatment period. An 11 point NPRS was used to assess pain throughout the night, at rest, and with active shoulder movements. Pain scores were taken at baseline, first week, and second week. After treatment, DASH scores were significantly lower in both groups compared to baseline which could be attributed to the HEP, modalities, KT or a combination. Although both groups showed significant change, the KT group yielded significantly lower results when compared to the PT group. The pain scores of the KT group were also significantly lower after week 1 compared to the PT group. Week 2 consisted of significantly decreased pain for both groups compared to baseline; however, there was no significant group difference in pain. According to Kaya et al. (2011), the results may have been attributed to the following effects: increased muscle strength, greater joint stability, assisted postural alignment, and relaxation the

overused muscles. Additionally, the immediate effect of KT may be considered as a very important advantage as compared with the PT modalities, and may increase athlete performance during exercise. In relation to shoulder pain, this study shows significant pain reduction when applying KT with a HEP. Similar and even greater results in pain and DASH scores were seen when using KT compared to traditional therapeutic modalities with both treatments including a HEP.

Further research on pain and function with the use of KT was conducted by Firth et al. (2010). Subjects included people with and without Achilles tendinopathy (AT). Athletes with AT are often treated with some type of increased structural support to help reduce AT symptoms. This method is often successful in reducing pain, but can sometimes be too restrictive for competitive athletes. KT may have the same effect on symptoms, yet be less restrictive. One possible effect of KT is an increase in functional performance of athletes according to Firth et al. (2010). The purpose of this study was to investigate the immediate effects of KT on a functionally relevant task, pain, and calf muscle excitability in healthy subjects and people with AT. A combination of 26 healthy individuals without any AT pathology and 29 people with AT were selected in this study. Each subject was taped along the Achilles tendon with KT using an AT correction technique with the subject's ankle in maximum active dorsiflexion. The effect on function and performance was measured with a single leg hop test with tape (immediate post taping) and without tape. Calf muscle excitability was assessed using the Hoffman reflex of the soleus and gastrocnemius muscles. Excitability was also recorded after tape removal. Pain was assessed with an 11 point NPRS. The results showed no significant change in hop distance or pain levels between the bare skin and taped procedures. Healthy subjects showed a significant increase in the Hoffman reflex after tape removal, whereas the patients with AT found no

significant change in the Hoffman reflex. In summary, the results showed no substantial evidence for the use of KT on the Achilles tendon for improved hop distance, decreased pain, or motoneuron excitability. Similar to other research regarding the excitability effect of KT on muscles, this study shows no significant evidence for increasing motoneuron stimulation (Alexander, McMullan, & Harrison, 2007). The use of the 11 point NPRS was a good determiner of the subjects own interpretation of the treatment in regards to pain.

The current research regarding the effects of KT on neurological conditions is sparse. However, it is not uncommon for individuals with shoulder pathologies to experience neurological symptoms locally or into their distal extremity such as with brachial plexus injuries. Kalichman, Vered, and Volchek (2010) researched the effects of KT on meralgia parasthetica, which is a condition involving symptoms of pain, paresthesia, and numbness in the lateral thigh. Pain and quality of life (QOL) were evaluated using a 100-mm VAS. The symptom area size was marked and measured. KT was applied twice a week for 4 weeks, without any other treatment. All outcome measures showed significant improvement after 4 weeks of KT treatment. Of the 10 subjects involved in the study, one who had relatively severe symptoms (QOL-100, pain-54) reported almost symptom free after KT treatment (QOL-22, pain-10). Although no subjects complained of worsening symptoms, four subjects only experienced a very modest change. One limitation in this study is the lack of a comparison group, which would help rule out the placebo effect.

González-Iglesias et al. (2009) also looked into the effects of KT on pain reduction for individuals with acute whiplash injury. Subjects completed an 11 point NPRS immediately after and 24 hours post KT application. A sham tape was applied without any tension. All subjects had no previous experience wearing KT and it was assumed that this would blind the subjects to the

purpose of the sham tape. Results showed a significant difference in pain reduction immediately and 24 hours post application for the therapeutic tape procedure compared to the sham procedure. The data however, did not surpass the minimal clinically important difference for pain, which has been reported to be at least 2 points on an 11 point NPRS (Thelen et al., 2008). In similar research looking into the changes of pain with the treatment of KT on the shoulder (immediate to 6 days post taping), no significant changes were found on an 11 point NPRS (Thelen et al., 2008). Cervical pain and ROM are often the most common symptoms associated with acute whiplash injury, suggesting that this study provides evidence for the use of KT to assist in slight reduction of acute pain and improvements in cervical ROM. Future research would help clarify if these effects could be of clinical significance and if similar results are seen in people with other injuries associated with altered pain and ROM.

A recent case study by Hwang-Bo et al. (2013) suggests that sedentary workers are most prone to work-related musculoskeletal disorders. Amongst these is rounded shoulder posture (RSP), which is simply an excessive forward shoulder posture. Sitting at a desk for too long causes increased fatigue of lumbar extensor muscles, resulting in poor slouching posture. The purpose of this study was to see if KT could decrease pain associated with RSP. In this case study, a 23 year old female who averaged 7 or more hours of sitting at work per day was measured for RSP on both the dominant and non-dominant shoulder sides using various methods. Pain was measured using an 11 point NPRS. The dominant side had greater RSP and reported greater pain (6/10) than the non-dominant side (1/10). The subject received KT along the upper back and shoulders with approximately 50% stretch for one month (six times per week). Each tape application was left on for approximately 16 hours. No other treatment, medication, or therapy was provided. Results showed a dramatic decrease in dominant upper

back pain and actually completely relieved the subject of pain (6/10 to 0/10). RSP results also improved after KT treatment, including changes in x-rays revealing improved shoulder and upper back posture. The authors discussed that a cause-and-effect relationship between pain and alignment is not yet clear, however, misalignment is an important factor commonly leading to mechanical pain. It was found that poor posture may be corrected with the use of KT over a one month period, and help decrease pain in sedentary individuals. Similar research has shown benefits of using KT to assist proper posture (Hsu et al., 2008; Van Herzeele et al., 2013). Future research is needed to test these findings on a larger population. Additionally the use of a placebo or sham tape application would increase the validity of future research.

Similar to the findings on shoulder posture, kinematics, and ROM, the influence of KT on pain is inconsistent among research. A study by González-Iglesias et al. (2009) has shown that KT can have an influence on pain reduction, but may not necessarily attain clinical significance. Yet a separate study did not see any changes in pain with KT treatment (Firth et al., 2010). However, the effects of KT exceeded the outcome of traditional therapeutic modalities on individuals with SIS (Kaya et al., 2011). There are many factors that can contribute to this inconsistency in research including: brand of tape used, taping technique, and the design of the study, not to mention the location, type, and severity of the injury. There is simply not enough up to date research on shoulder pain to determine if KT can be considered a trusted treatment option for health care professionals.

Functional Performance, Muscle Excitability, and Other Related Factors

Even though the cause for sports injuries and re-injuries can be related to a number of issues, the prevention or recovery process after an injury often includes bracing and/or protective taping to prevent re-injury. While these modalities can be helpful, they can also be restrictive,

bulky, and uncomfortable which can contribute to a decrease in performance. Due to lack of extensibility, standard athletic taping has been shown to inhibit necessary movement at a joint (Alexander, Stynes, Thomas, Lewis, & Harrison, 2003). Aktas and Baltaci (2011) hypothesize that a possible cause for lower extremity injuries, specifically the knee, may be attributed to the impaired athletic performance of individuals wearing preventative lower extremity braces. KT might be a more functional choice of prevention of injury or re-injury due to its ability to move with, not against, the body with complex sport specific movements. The purpose of their study was to determine if using a brace, KT, or both will have the greatest effect on muscular strength and functional performance at the knee. Subjects (ages 21-24) without any recent history of lower extremity pathologies were tested. Standard patellofemoral stability correction and quadriceps knee KT (Kinesio Tape®) were applied with the subject's leg and knee on a stretch. The patellar strips included a 50-75% stretch. A DonJoy Tru Pull brace was the brace of choice in this study due to its patellar stability straps. Isokinetic quadriceps knee strength, vertical jump, and one legged hop test were all measured with the dominant and non-dominant leg. Each test was performed with a bare knee, preventative bracing only, KT only, and KT with preventative bracing. The results of this study demonstrated an increase in one legged hop distance with the dominant leg for males, as well as the non-dominant leg for females, with application of KT, and KT with bracing, as compared to the control (bare knee) condition. Additionally, in the isokinetic testing of the quadriceps at 180°/s, KT alone yielded the greatest improvement. KT alone recorded greater values than knee brace, and knee brace with KT as well. There were no significant differences for the same test at 60°/s. There were also no significant differences in vertical jump height between groups. Implications of these results show that KT may have higher functional results than bracing specifically in the knee. KT has shown to enhance muscular

output, acting as a more functional treatment option (Slupik et al., 2007). While braces may be limiting performance, results were clear that KT did not inhibit performance nor inhibit muscular contraction potential. However, the primary purpose of bracing is to limit pain and decrease risk of injury, and neither of these factors were measured in this study. Additionally, all subjects were healthy and had no recent history of knee injury. Future research on individuals with actual knee pain that require bracing would be more helpful.

Due to the many potential benefits of KT, the methods to measure them are just as vast. One commonly researched topic with KT is muscle strength. Although the effects of KT on muscle strength are inconsistent among research, the methods by which it is studied can be replicated for similar purposes. In a study by Merino-Marban, Mayorga-Vega, and Fernandez-Rodríguez (2012), maximum grip strength was measured by the use of a digital hand dynamometer. Comparisons were made from grip strength in one hand to the other, with only one forearm having KT application. In addition, comfort of wearing the tape was assessed with an 11 point rating scale. The scores ranged from 0= "very uncomfortable" to 10= "very comfortable." Similar scales measuring quality of life have been used in other research (Kalichman et al., 2010). Subjects completed comfort level scales 15 minutes after KT application and after wearing KT for 48 hours. Similarly, grip strength was measured without tape, 15 minutes after taping, 48 hours after taping, and 15 minutes after tape removal. Results showed no significant difference in grip strength over the 48 hours from KT application. Similarly, there was no significant data to show any changes in comfort level over the 48 hour period. According to the authors, the comfort levels remained very high throughout the duration of wearing KT averaging 9.15 ± 1.03 after 15 minutes of KT, and 9.19 ± 0.92 after 48 hours of wearing KT. The use of an 11 point comfort scale gave subjects another tool to describe their

overall experience with KT. It allowed subjects to voice some subjective responses besides just pain, which some studies lack. This study did not support the use of KT for increasing grip strength in healthy individuals over a 48 hour period.

KT has been thought to improve the stimulating effect on skin receptors which moves and raises the skin in appropriate directions (Slupik et al., 2007). The purpose of their study was to determine the effects of KT on changes in the tone of the vastus medialis muscle during isometric contractions. Protocol 1 included 27 healthy people (average age 23 years) without any knee pain and included testing at the following times: baseline, 10 minutes after tape application, 24 hours, 72 hours, and 96 hours post application. Two KT strips were applied along the vastus medialis muscle from the origin to insertion. Protocol 2 included 9 people (average age 24.9 years) without any knee pain. This protocol involved EMG measurements before treatment and 24 hours after treatment for peak torque of isometric knee extension (held for 3 seconds, 5 repetitions total). Following the second measurement, the tape was removed and EMG was performed again. This study showed an insignificant difference in muscle strength 10 minutes after the tape was applied. However, a gradual increase was seen over time with muscle strength. The tape's effects were short lived and didn't make a difference after 3-4 days. The subjects who saw an increased effect had a similar increase in results 48 hours after the KT was removed. This could be explained by familiarization to the design. The findings in this study do not clearly show evidence for or against the use of KT in improving isometric knee extension during a 96-hour period.

Inconsistent results concerning the effects of KT on muscle strength were found in studies by Vercelli et al. (2012), and Fu, Wong, Pei, Wu, Chou, and Lin (2008). The purpose of these studies was to measure the immediate effects of KT on lower extremity muscle strength of

healthy subjects using an isokinetic dynamometer. All subjects were healthy and without lower extremity injury. Three separate taping procedures were included in the study by Vercelli et al. (2012). The first was a facilitative taping to increase muscle strength. This was applied proximal to distal with approximately 25-50% tape stretch. The second was an inhibition taping to inhibit muscle strength. This was applied distal to proximal with approximately 15-25% tape stretch. The third was a sham taping to represent no effect. This was applied without any tape stretch and placed perpendicular to the quadriceps. Data was taken by three separate tests including: isokinetic peak torque test, single-leg triple hop, and a global rating of change scale. All tests were performed with each type of taping procedure. Results revealed no significant effect with KT on quadriceps strength including all three types of taping procedures. KT application in the study by Fu et al. (2008) was located on the quadriceps only (Y strip with 120% stretch), yet the quadriceps and hamstring muscle groups were both tested for strength. Contrary to the claim that tape applied under tension in the direction of muscle fibers facilitates the strength of the underlying muscle, the results of these studies suggest no influence in promoting or inhibiting muscle strength when applied with KT. The recommendations provided specifically for Kinesio® Tape, as used in the study by Fu et al. (2008), suggest at least 30 minutes from tape application to the beginning of exercise according to their website. The purpose is to allow adequate time for the tape to adhere to the skin prior to sweating. Testing the effects of KT immediately after tape application is contraindicated to the given instructions, and may not have provided the best representation of the tape's effectiveness.

In summary, this subtopic of functional movement and muscle excitability in relation to KT has shown inconsistent results. Improper muscular strength and recruitment are commonly associated with shoulder injuries. There is evidence both for and against the notion that KT can

aid in this process, yet its significance in treating shoulder symptoms is also unknown.

Therefore, further research specifically on individuals with injured shoulder will help to clarify this uncertainty.

Conclusion

The use of KT is growing amidst the lack of consistent research to support its effectiveness. KT is difficult to study and measure because it has been labeled to treat such a wide variety of injuries in many different ways. Additionally, the placebo effect for this treatment is sometimes known as the only true effect. There are many possible benefits of using KT which include: soft tissue healing, anatomical structural support, muscle recruitment, and increased proprioceptive responses (Thelen et al., 2008). The current knowledge base with KT varies across different studies designs with differing purposes for using KT. As seen in this review, the effects of KT on pain and ROM have shown to be both advantageous as well as non-existent. The application procedures, design procedures, specific brand of KT, longevity of KT, and overall effectiveness have varied across research. Until evidence based practice can provide consistent results, many health care professionals will still have questions regarding the therapeutic benefits of KT. This is why there is a need for further research.

The popularity of KT has grown due to its anecdotal success and vast amount of uses on the human body. Initially, KT was made as a treatment option for injury. As the effects of KT continue to be discovered across the sports spectrum, it is seen in research that KT may also have benefits for active healthy individuals (Aktas & Baltaci, 2011; Firth et al., 2010; Ujino et al., 2013; Van Herzeele et al., 2013; Yoshida & Kahanov, 2007). The uses for KT have expanded from simple treatment for injury into an ergogenic aid among athletes. This is evident by the research of KT on healthy individuals and athletic performance related variables such as muscle

strength, ROM, and increased proprioception (Slupik et al., 2007). KT may be a way of assisting in the same traditional goals clinical professionals and athletes have sought after for decades.

With the high prevalence of shoulder injuries in the athletic population and due to its consequence of decreasing sports performance, it is important to research potential treatment options. KT is indicated as a treatment option for a variety of sports injuries and its relationship specifically to shoulder injuries needs more clarification in research. As functional athletic tape, KT may assist in reducing pain and treating shoulder injuries. There is not yet an adequate amount of research to fully understand the effects of KT, specifically on shoulder injuries. With the limitations seen in this literature review, it will be helpful to conduct new research which will apply new methods with up to date technology to assess if KT can influence shoulder pain and ROM during functional sport specific movements.

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