THE EFFECTS OF SELF-ADHERENT TAPING ON PEAK INVERSION ANGLE AND EVERSION MOMENT UPON LANDING DURING A MAXIMAL VERTICAL JUMP AND A DEPTH DROP

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A Thesis Presented to

The Faculty of Humboldt State University

In partial fulfillment of the Requirements for the Degree

Master of Science in Kinesiology

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May 2018

ABSTRACT

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Ankle injuries are the most common injury in physically active adults with roughly 15% to 30% of all physical activity injuries being ankle injuries. The purpose of this study is to evaluate the effectiveness of a self-adherent ankle taping in reducing peak ankle inversion angle and peak ankle eversion moment upon landing during a max vertical jump and depth drop compared to jumping without a prophylactic ankle stabilizer.

Twelve volunteers participated in testing procedure on two separate days. Day one consisted of orientation while day two consisted of experimental data collection. The participant's peak inversion angle and eversion moment were measured using 3D motion capture software and force plates during landing from a maximal vertical jump and depth drop.

In support of our hypothesis, peak ankle inversion angle during landing decreased 19% as a result of wearing self-adhesive tape when compared to adhesive tape ($p = .002$). Additionally, peak inversion angle upon landing from a depth drop was 20% less with self-adherent tape as compared to adhesive tape ($p = .018$). Despite the differences in peak inversion angles, the subjects experienced nearly identical peak ankle eversion

moments during the landing phase of both a vertical jump as well as a depth drop both before and after exercise.

In conclusion, self-adherent tape showed promise as an alternative to standard adhesive tape in restricting peak ankle inversion. When comparing self-adhesive tape to adhesive tape, the difference in peak inversion angle remains the only advantage of self-adherent tape found by this study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

CHAPTER ONE: INTRODUCTION

Athletes face a chronic issue of sacrificing their body for sake of the sport. An athlete's ability to play throughout an entire season can easily depend on whether or not they can remain physically healthy enough for participation. An athlete's main concern during sport is usually not in regards to their own health and safety. A lot of athletes intentions lie within having a good performance, and more importantly, securing a win. However, even though athletes may not be thinking about the risks involved, injuries happen far too often. Injuries will range in severity, some only requiring a simple bandage, while others may require a trip to the hospital.

There has been a lot of research and application on different methods of injury prevention techniques. Some examples of injury prevention practices are weight lifting guidelines to help strengthen athletes, or even the PEP program to aid in preventing ACL sprains. However, one of the most common injury prevention tactics is using prophylactic ankle support to help inhibit ankle sprains. Two of the most commonly used prophylactic supports are taping using cloth tape and ankle braces. A probable reason behind ankle support usage may be the magnitude of ankle injuries.

Approximately 25,000 Americans suffer from an ankle sprain each day (Ibrahim, Meyler, & Panagos, 2015), in which the lateral ligaments are the most commonly sprained (Pederson, Ricard, Merrill, Schulthies, & Allsen, 1997). Ankle injuries are the most common joint injury seen in sports medicine, general orthopedics, family practice, or general medicine (Childs, 2007). Ankle injuries are also the most common injury in physically active adults (Purcell, Schuckman, Docherty, Schrader, & Poppy, 2009) with roughly 15% to 30% of all physical activity injuries being ankle injuries (Ambegaonkar et al., 2011). The sprained ankle has an estimated occurrence rate of 1 per 10,000 persons per day (Mabee & Mabee, 2008) with an even higher rate of 32.8 per 1000 exposures for athletes when not wearing any external support (Purcell et al., 2009). Of all ankle injury occurrences, 80% are due to an inversion mechanism (Ibrahim et al., 2015).

Causes of ankle injuries include, but are not limited to: running, pivoting/planting, uneven ground, repetitive trauma, and forced range of motions (landing on another person's foot, or blunt trauma). One common movement during sports that predisposes ankles to injury is jumping. During a jump, the natural movement of the foot will assume a plantar flexed and inverted position (Mabee & Mabee, 2008). Sports that require a lot of cutting, jumping, or physical contact may contribute to the ankle to be forced into inversion and plantar flexion. Most ankle inversion injuries will occur during landing with the foot plantar flexed and internally rotated (defined as inversion)(Ricard, Sherwood, Schulthies, & Knight, 2000). This natural movement during a jump compromises the athlete's ability to hold a neutral position, which affects their ability to land in an unaltered anatomical position. For this study, the anatomical position, or a neutral position, will be described as the ankle joint having zero degrees of inversion and zero degrees of eversion.

Athletic trainers and athletes all over the world are depending on the range of motion limitations provided by ankle taping or ankle bracing on a daily basis. An immense amount of time and money is being committed to this style of stabilization, but is it the most effective? There is substantial amount of literature in support of and against the use of ankle taping and ankle bracing. This study will help provide new knowledge regarding the effectiveness of self-adherent tape in preventing the inversion motion at the ankle.

The significance of this study is that it will help solidify previous studies findings, as well as providing new information regarding the effectiveness of self-adherent tape on stabilizing the ankle.. The effectiveness and/or ineffectiveness of a cloth ankle taping will be evaluated in comparison to a self-adherent ankle taping. This study will help answer the question of what method of stabilization is the best option to reduce inversion angle and eversion moment.

Statement of the Problem

Athletic trainers, along with the rest of the sports medicine team, recognize that there is a need for injury prevention to help minimalize time lost from competition (Lindley & Kernozek, 1995). Ankle taping using cloth tape, as well as bracing, has been the common practice of both athletic trainers and athletes alike to provide external ankle support. Cloth tape is currently used to aid in prevention of ankle injuries, as well as in treatment of current ankle injuries. Taping and bracing have shown to cause a significant decrease in ankle inversion, eversion, plantar flexion and dorsiflexion. Reducing ankle range of motion using either support method lessens the frequency of ankle injury (Pederson et al., 1997). Even though these methods of stabilization (cloth tape and bracing) are widely used throughout the athletic community, preference of which to use is still widely disputed. Some doubt lies in the fact that cloth taping is known to not hold significant range of motion restrictions throughout the duration of a competition. While bracing seems to be a more secure option, athletes often do not apply the braces properly, or readjust them as needed throughout competition. These issues suggest there is a need for a better prophylactic support option.

Overall Purpose of Tape + History of Use

As written above, athletes had 32.8 ankle sprain incidences per 1000 exposures when there was not a prophylactic stabilizer on the ankle. However, that number decreases from 32.8 to 14.7 when an ankle taping was employed (Purcell et al., 2009). It has been assumed that taping an ankle is effective in preventing ankle injuries because of the increased structural support provided to the ankle joint. With that being said, the structural support of an ankle tape and its ability to limit range of motion has also been widely studied. The purpose of external supports, such as taping, help support ankle ligaments by limiting range of motion, increasing proprioceptive feedback, and also by compressing and limiting the motion of muscle-tendon units (Ambegaonkar et al., 2011). Ankle range of motion in all planes has been shown to significantly decrease immediately after tape application. More specifically, ankle inversion and eversion is reduced by 37% and 32%, respectively (Purcell et al., 2009). However, the problem with cloth athletic tape is that it has been shown to loosen over time, decreasing its overall effectiveness in preventing injuries to the ankle. Some research claims that cloth tape fails to maintain a consistent amount of support throughout extended periods of activity (Lindley &

Kernozek, 1995). Even though the initial response is good, several researchers report that within 30-60 minutes, a cloth ankle tape job will loosen significantly (Ambegaonkar et al., 2011). Some studies show a much quicker time, requiring only 10 minutes of exercise before the tape loses its restrictive properties (Cordova, Ingersoll, & LeBlanc, 2000; Purcell et al., 2009). Cordova performed a meta-analysis looking at range of motion in 2000 athletes, and quantified pre- and post-exercise measurements. Pre-exercise data for inversion (measured in degrees) was as follows: Control – 48.3±6.8°, Cloth Tape – 27.5±6.4°, Lace-up Brace – 30.2 ±5.6° (Cordova et al., 2000). Post-exercise data in the same study was as follows: Control – 34.6±6.3°, Cloth Tape – 36.1±7.0°, Lace-up Brace – 41.5±5.3° (Cordova et al., 2000). These numbers show that both cloth tape and lace-up bracing decreased range of motion by approximately nine degrees (Cordova et al., 2000). This study did not show range of motion changes at certain time intervals, so it is difficult to determine at what time the restrictive properties were lost. However, Cordova deduced through his study that moderate intensity exercise greater than ten minutes is “sufficient enough to cause weakening of softer support (tape and lace-up braces), leading to less joint restriction (Cordova et al., 2000).” Opponents of ankle tape suggest that the decrease of stabilization does not sufficiently protect the ankle from injury. Many factors could affect the loosening of ankle taping. The most common culprit is perspiration, causing an overall decrease in tape strength, as well as causing the tape to lose its adhesive properties (Purcell et al., 2009). With this concept of perspiration being a cause of adhesive degradation, a self-adherent tape may prove to be superior.

Overall Purpose of Bracing + History of Use

Similar to prophylactic ankle taping, ankle bracing has been used to help reduce overall occurrence and severity of ankle injuries. Similar to tape, ankle bracing is used for limiting excessive or abnormal kinematic ankle movement and providing proprioceptive feedback (Ambegaonkar et al., 2011). Ankle braces were partially developed to help address the loosening properties of cloth tape (Willeford, Stanek, & McLoda, 2018). Another reason ankle bracing gained interest was due to its cost and time efficiency. Cloth tape must be continually purchased due to the fact that it cannot be reused like a brace. The brand “Active Ankle” states that their lace-up braces can last up to one full season ("Active Ankle," 2016). Taping also requires time from another person to apply it. Ankle bracing can be applied by the athlete without the assistance of another person. A study that tracked ankle injuries and re-injuries determined that lace-up ankle braces had approximately half the risk of injury over athletes who wore cloth tape (Willeford et al., 2018). In contrast, some studies show the lace-up braces lose restrictive properties at a similar rate to cloth tape (Willeford et al., 2018). The numbers from Cordova’s meta-analysis apply here as well. Lace-up bracing, though effective immediately (approximately 13% better than control), loses range of motion restriction after approximately ten minutes (Cordova et al., 2000). The data shows that cloth tape and lace-up braces are both equally effective when compared to one another, but there is still room for a better prophylactic support (Cordova et al., 2000).

Prophylactic Support + Performance

With the range of motion restrictions we see with prophylactic ankle support, conversation has been sparked as to whether or not performance will be negatively impacted. Some areas of concern include agility, sprint speed, and vertical jump. Investigators of athletic performance variables have not reported any remarkable difference in loss of or gain of performance as a result of wearing athletic tape versus bracing for the ankles (Hodgson, Tis, Cobb, & Higbie, 2005). In a study testing three different types of ankle braces, vertical jump was not hampered for any of the methods of bracing (Ambegaonkar et al., 2011). Participants all had similar vertical jump heights ($P = .27$). With these results, it is arguably safe to say that due to different ankle prophylactic supports, performance should not be hindered in any way that would influence the study.

Self-Adherent Tape

Self-adherent tape is a newer product in the sports medicine community. Limited research has been completed in regards to self-adherent tape and its proposed effects. Part of the reason self-adherent tape was designed was to help address the stability flaws of standard cloth tape (Willeford et al., 2018). Self-adherent tape is designed to work together with a self-adherent pre-wrap and the combination of these two products is believed to uphold range of motion restrictions throughout exercise ("Cohesive Bandages," 2015). One of the biggest reasons why self-adherent tape is believed to be superior to cloth tape is due to the fact that it is water resistant (Purcell et al., 2009). One brand of self-adherent tape, “Power Tape™” by Andover, claims that the tape has “less than one percent stretch, far more superior to cloth tape" ("Cohesive Bandages," 2015). They also state that these increased strength and water resistant properties are due in part to the combined use with PowerFlex, a self-adherent pre-wrap ("Cohesive Bandages," 2015). Though the increased strength and water resistant properties will not be tested in this study, they could be the reason for the suggested prolonged stabilization. However, Willeford conducted a study that showed "self-adherent tape and lace up ankle braces provided equal range of motion restriction before and after exercise (2018)."

Purpose of the Study

The purpose of this study is to examine the effectiveness of self-adherent tape in controlling peak inversion angle and eversion moment compared to traditional cloth tape and no bracing (control) when landing from a vertical jump and a depth drop. Athletic tape is a commonly used application for helping prevent and treat ankle injuries. Some research gives credibility to the method of stabilization. However, there is also research questioning its reliability and effectiveness. Self-adherent tape may prove to be a better means of stabilizing the ankle. However, the effectiveness of self-adherent tape in reducing inversion motion and moment during landing remains unclear; especially in comparison to the traditional ankle stabilization modality of adhesive taping.

Hypothesis

H1: Self-adherent tape will reduce peak ankle inversion angle and peak ankle eversion moment upon landing during a max vertical jump and depth drop compared to jumping with without ankle stabilization.

H2: Self-adherent tape will reduce peak ankle inversion angle and peak ankle eversion moment to a greater amount as compared to traditional cloth tape during the landing phases of a maximum vertical jump or depth drop.

CHAPTER 2: METHODS

Participants

The study consisted of 24 (male and female) collegiate basketball players, ages 18-35 years (mean ±SD). All subjects were volunteers and met the criteria of being in general good health, without having any previous injuries that could alter their performance within the study. Injuries of this nature will pertain to, but are not limited to: improperly healed or rehabilitated injuries to the ankle, range of motion not within normal limits at the ankle, bilateral imbalance of strength, and or any recent injury (within the past two months) to the ankle, knee, hip or any other body part that would impede vertical jump performance. All of the participants were collegiate basketball players at Humboldt State University. A health questionnaire was utilized to determine any recent injuries or health issues that may have occurred within the last six months (See Appendix A). All participants were asked to wear the same team issued basketball shoes for the exercise portion of the study. The athletes did not wear socks or shoes during the jump trials, only during the exercise regimen. All participants provided informed consent prior to participation in the study.

Research Design

This study is a true experimental design with randomized conditions. This study analyzed the effect of two different prophylactic ankle stabilizers on kinematics and moment of the ankle during landing from a vertical jump and depth drop. The study was counterbalanced for the vertical jump and depth drop variable. Half of the subjects performed the vertical jumps first, and the depth drops second. The other half of the subjects flipped this order, performing the depth drops first, and the vertical jumps second. Tape conditions were also counterbalanced. Order of control, adhesive, and self-adhesive tape were randomized and balanced between all subjects.

Procedures

The research project took place on two separate days. The first day consisted of an orientation and a preliminary jump session, whereas the second day experimental data was collected. All of the experimental data collection jump sessions occurred on the same day for each subject.

The first day of the study was primarily for introduction to the research project, but also to obtain vertical jump heights and anthropometric measurements from each participant. The vertical jump heights were used to set the depth drop height. An orientation was given to all participating subjects including an explanation regarding the number of participants, the time commitment, confidentiality, as well as the risks and benefits of the study. Participants were informed that their participation was completely voluntary and that they were free to decline participation at any time during the study. All participants provided informed written consent (Appendix A) prior to commencement of the study once the information had been given to them. After consent had been obtained, each participant performed three maximal vertical jumps measured with a “Vertec” measuring device. The best of each participant’s scores was taken and used to determine the average maximal jump height for all participants. This average was used to set the height of the depth drop; i.e. 75% of average maximal jump height.

The second visit was for the experimental data collection. In this session subjects performed three maximal vertical jumps and three depth drops for each ankle stabilization condition before and after exercise. Identical procedures were used for each jump trial, with the only difference being the method of stabilization. The same Certified Athletic Trainer applied all prophylactic supports bilaterally throughout the duration of the study. The adhesive ankle tape method was the "Closed Gibney" with both figure of eights and heel locks, which is the most common style for both prevention and treatment of ankle injuries. The self-adherent tape using PowerTape and Powerflex also consisted of a "Closed Gibney" tape job with both figure eights and heel locks. Subjects wore reflective markers during each of their vertical jump and depth drop tests to help analyze the data using the motion capture software. The markers were placed on them using a cluster model once they were taped. Skin marker locations are as follows (for both left and right sides when applicable): C7, T10, right back, sternum, clavicle, ASIS, PSIS, medial and lateral knee, medial and lateral malleoli, heel, 5th metatarsal, 1st metatarsal, midfoot. Cluster marker locations were placed on the thigh and leg for both left and right sides. After the pre-exercise jump trial is over, the foot markers and cluster markers were removed for the exercise regimen (all other non-cluster markers were left on during exercise). The markers and clusters that were removed were then reapplied prior to the subject's post-exercise trials.

Prior to the jump landing trials, subjects performed dynamic warm-ups consisting of heel/toe walking (ten yards each), bodyweight squats (ten), lunges (five each leg), straight leg kicks (ten yards), high skips (ten yards), and backpedaling (ten yards). Moreover, following the pre-exercise jump landing trials, subjects performed a fifteen-minute functional exercise regimen known as the modified Illinois Agility Test (See Appendix B). The agility test was turned into a continuous loop so that the subjects could maintain a consistent pattern throughout the exercise duration. The subjects ran at a sub-maximal pace for seven and a half minutes in one direction, then seven and a half minutes in the other direction. Pace was monitored using a Rated Perceived Exertion Scale (RPE). Subjects were instructed to exercise at an RPE level of three throughout the functional exercise segment. An RPE level of three is defined as being moderate exercise ("Rated Perceived Exertion (RPE) Scale," 2017). The subject's RPE level were monitored at six separate times. The six recordings took place during: 1. The first lap 2. The two-minute mark 3. The five-minute, thirty-second mark 4. The seven-minute, thirty-second mark 5. The nine-minute, thirty-second mark 6. The thirteen-minute mark. If the participant needed to take a break during the functional exercise portion, they were granted time to do so, but not allowed to walk around as to keep the tape from any additional stresses. Water was onsite for the subjects as needed.

Each jump session consisted of three maximal vertical jump attempts and three attempts at the depth drop test. The subjects jumped and landed with each foot on a different force plate in order to acquire separate measures for each limb. If the subjects did not land on separate force plates, they performed subsequent jumps/drops until they did so (maximum of five jumps). If the subjects did not successfully land on two separate force plates within five attempts, they were re-taped and started the sequence over from the beginning. Note was taken of the number of jumps each subject took over the allotted three jumps and if they had to retest. Once three trials had been recorded for both the vertical jump and the depth drop, and at least one successful trial had been recorded for each, the tape was removed and the subject's day was over.

Methods for each day went as follows:

1. Perform dynamic warm-up/stretching
2. Application of supportive device (cloth tape, self-adherent tape, or none)
3. Application of skin and cluster markers
4. Perform pre-exercise jump/drop trials (Pre-exercise data)
5. Remove foot skin markers and cluster markers
6. Perform functional exercise
7. Re-application of necessary markers
8. Perform post-exercise jump/drop trials (Post-exercise data)
9. Remove foot markers and tape
10. Repeat steps 2-9 until all three tape conditions have been completed

Measurements/Instrumentation

Vertical jump height was measured in inches using a "Vertec" measuring device. The height of the depth drop was set to 75% of the average maximal vertical jump height for each gender taken on the first day of the study. Based on the averages, the male subject's drop height was set at 25 inches while the female drop height was set at 15 inches.

All lower body kinematics were measured using 3D digital motion capture (120 field/s, T-10 Vicon, Centennial, CO) and reflective markers were placed on the entire body (minus the arms and head) using a cluster model. We digitized the markers (Vicon Nexus, Centennial, CO, USA) and filtered the position data using a fourth-order zero-lag Butterworth filter with a cutoff frequency of 6 Hz (Winter, 1990). From the position data, we calculated lower limb kinematics in the sagittal and frontal planes for each jump and drop trial. Ankle joint angle was defined as the acute angle between adjacent segments whereby positive motion is represented by plantar flexion (ankle) or inversion.

Center of mass was measured by utilizing vertical ground reaction forces for each jump trial taken from force platform (Model OR6-7, AMTI, Watertown, Maine). Force data was collected with a sampling rate of 1000 Hz and low-pass filtered the data using a fourth-order zero-lag Butterworth filter with a cutoff frequency of 20 Hz. In this study, dividing the measured GRF by the subject's body weight will normalize the ground reaction force, and BW was used as the unit. We also used the filtered vertical ground reaction force data to calculate the acceleration of the center of mass in each direction. We then double integrated the acceleration data with respect to time for each jump to determine the instantaneous center of mass vertical velocity and displacement during the ground contact phase of the jump (Blickhan & Full, 1993; Bot & Van Mechelen, 1999; Linthorne, 2001). We then used ground reaction force, lower limb kinematic measurements and inverse dynamic equations to calculate eversion moment of each ankle during the landing phase of each jump. For each jump we calculated the average and peak ground reaction force, inversion angle, and ankle joint moment. We then used these values to calculate the means of each variable across all four trials of each jump (vertical jump and depth drop) for each condition.

Independent Variables

The two with-in subjects independent variables for this study include taping conditions (control-no tape administered), cloth tape, and self-adherent tape) and exercise (pre-exercise or post-exercise).

Dependent Variables

Dependent variables for this study are peak inversion angle (deg.) and eversion moment (Nm.) during the landing phase.

Statistical Analysis

IBM SPSS 25 (City and State) was used to run the statistical analysis to identify any alteration in the dependent variables. The independent variables were the three tape conditions (control, adhesive, and self-adhesive), and exercise (pre and post exercise). For this study, the effects of tape condition and exercise on landing kinematics and kinetics were analyzed separately for the maximal jump landing and depth drop landing. Specifically, two-way repeated measures ANOVAs were performed on each of the dependent variables: peak ankle inversion angle and peak ankle eversion moment. When appropriate post-hoc analysis were performed using Bonferroni correction to identify specific differences among the tape conditions. An alpha level of .05 was used to determine significance. All data is reported as mean ± standard error of the mean, unless otherwise stated.

Operational Definitions

Maximum Vertical Jump: Standing, no step vertical jump. Participants jump as high as they can while being able to land on two separate force plates. Counter movements are allowed to start the jump.

Depth Drop: Stepping off a platform (with a set height) and landing on separate force plates with both feet simultaneously.

Landing Phase: The last phase of a jump from time of foot contact to of the time when center of mass is at its lowest vertical position.

Plantarflexion: Flexion of the ankle joint so that the toes and plantar surface of the foot rotates downwards.

Dorsiflexion: Flexion of the ankle joint so that the toes and plantar surface of the foot rotates upwards.

Inversion: Movement in which the plantar surface (sole) of the foot rotates towards the mid-line of the body.

Eversion: Movement in which the plantar surface (sole) of the foot rotates away from the mid-line of the body.

Peak Inversion Angle (degree): Greatest angle of inversion achieved during landing phase of jump.

Peak Ankle Eversion Moment (Nm): The peak external ankle joint moment in the direction of eversion across the entire landing phase of a jump.

("IvyRose Holistic Homepage," 2016)

Assumptions

1. Inversion during a vertical jump predisposes a subject to sustain an ankle injury.
2. The subjects gave their best effort during all maximum vertical jump attempts.
3. The motion analysis software to measure inversion was sensitive enough to measure inversion movements of the ankle.
4. The force plates are sensitive enough to measure individual GRF measurements.
5. All tape applications were equal in technique and tightness for all participants.

Limitations

1. Participant's ability to land on two separate force plates while maintaining a natural jump and landing motion.
2. Participants vertical jump heights may be different heights due to skill level.
3. The consistency of the ankle taping and bracing applications may differ among subjects. If the tape, cloth or self-adherent, was not consistently applied for all participants, differences in findings could occur.

Delimitations

1. This study excluded participants if they had any previous injury that affected their vertical jump or landing capabilities.

2. This study only included the use of two brands of tape.
3. The functional exercises administered in this study did not include actual game play. Accurate depictions of game/practice conditions were not fully achieved.
4. Only collegiate basketball players will be used in this study. A larger sample size consisting of more sports may yield different results.

CHAPTER 3: RESULTS

Subject Demographics

Twelve participants completed the study. A total of 24 people were screened, 12 were included, nine were excluded, and three decided to withdraw from the study. Descriptive information about the subjects is provided below (Table 1).

Table 1: Subject Demographics (Mean + SD)

Gender	n	Age (yrs)	Height (M)	Weight (Kg)	Jump Height (Inches)	75% Jump Height (Inches)
Male	6	21.3 ± 1.9	1.9 ± .15	90.5 ± 16.7	32.9 ± 3.0	24.7
Female	6	21.5 ± 2.1	1.7 ± .15	65.1 ± 16.4	20.2 ± 3.4	15.2

Peak Inversion Angle

Although not statistically significant, peak ankle inversion angle tended to change as a result of ankle taping (p = .051, partial η^2 = .277). Specifically, peak ankle inversion angle during landing from a vertical jump decreased 19% as a result of wearing self-adhesive tape when compared to adhesive tape (p = .002), but not when compared to the control group (p = .257). We observed no main effect for exercise (p = .141, partial η^2 = .186) or an interaction between exercise and taping on peak inversion angle during maximal jump landing (p = .592, partial η^2 = .034). Further in support of our hypothesis, there were main effects for both tape condition (p = .028, partial η^2 = .277) and exercise

(p = .003, partial η^2 = .574). Specifically, peak inversion angle upon landing from a depth drop was 20% less with self-adherent tape as compared to adhesive tape (p = .018). However, in opposition of our hypothesis, self-adherent tape did not yield a difference when compared to the control group (p = 1.000). We did not observe an interaction between tape condition and exercise (p = .545, partial η^2 = .054) on the peak inversion angle during depth drop landing.

Peak Eversion Moment

Despite the differences in peak inversion angles, the subjects experienced nearly identical peak ankle eversion moments during the landing phase of both a vertical jump as well as a depth drop both before and after exercise (Table 3). Specifically, difference in tape condition had no effect on peak eversion moment during maximum vertical jump landing (p = .704, partial η^2 = .031) or depth drop landing (p = .885, partial η^2 = .011). Similarly, exercise did not affect eversion moment during either the maximum vertical jump (p= .075, partial η^2 .260) or depth drop landing (p= .344, partial η^2 = .082). Last, we observed no tape condition by exercise interaction effect on peak ankle eversion moment during maximum vertical jump landing (p = .195, partial η^2 = .138) or depth drop landing (p = .340, partial η^2 = .094).

Table 2: Average Peak Inversion Angle ± SEM

Tape Condition	Jump Pre-Ex.	Jump Post-Ex.	Drop Pre-Ex.	Drop Post-Ex.
Control	8.37 ± 1.40	9.07 ± 1.09	6.96 ± 1.00	8.67 ± 0.95
Adhesive	8.98 ± 0.88	9.52 ± 0.66	9.06 ± 0.60	9.64 ± 0.87
Self-Adhesive	6.24 ± 0.91	7.89 ± 1.04	6.25 ± 0.79	7.89 ± 0.51

Table 3: Average Peak Eversion Moment ± SEM

Tape Condition	Jump Pre-Ex.	Jump Post-Ex.	Drop Pre-Ex.	Drop Post-Ex.
Control	-22.93 ± 4.11	-23.72 ± 3.93	-24.05 ± 4.27	-21.05 ± 2.53
Adhesive	-19.21 ± 2.62	-27.78 ± 4.43	-20.29 ± 1.64	-22.84 ± 3.39
Self-Adhesive	-24.87 ± 4.12	-25.68 ± 3.36	-23.86 ± 2.89	-20.41 ± 2.36

CHAPTER 4: DISCUSSION AND CONCLUSION

Discussion

In this study, we distinguished the effects of three taping conditions and an exercise regimen on peak ankle inversion angle and peak ankle eversion moment when landing from a maximum vertical jump and a depth drop. In contrast to our hypotheses, the use of self-adherent ankle tape did not affect peak ankle inversion angle or eversion moment compared to our control condition (no tape). While the use of self-adherent tape did reduce peak ankle inversion angle when compared to adhesive tape, it did not affect peak eversion moment.

This study showed that the use of self-adherent tape decreased ankle inversion by 19% and 20% when landing from a vertical jump and depth drop, respectively, when compared to adhesive tape. Using a dynamic test (jump and drop landing) in the measurement of ankle kinematics while supported with self-adherent tape is what makes this study unique from others. Studies produced by Purcell et al. and Willeford et al., both tested self-adherent tape pre- and post-exercise using goniometric tools to take their inversion measurements (Purcell et al., 2009; Willeford et al., 2018). Due to the nature of goniometer measurements, subjects had to be seated in a static position. This produced a much larger range of motion measurement than that of our dynamic landing test. Specifically, Purcell et al. (2009) and Willeford et al. (2018) observed average pre-exercise inversion ROM of 20-22 degrees when using self-adherent tape where as the current study observed a much lower average of 6.25 degrees in ankle inversion ROM. A similar difference between studies was observed for post exercise ROM measurements. Purcell et al. (2009) and Willeford et al. (2018) showed 24-25 degrees of inversion ROM, while this study produced a measurement average of 7.89 degrees (average of both jump and drop tests). Similar to our study, Purcell showed a significant difference between self-adherent tape and adhesive tape post-exercise (Purcell et al., 2009). This notable difference may be due to exercise breaking down the structural integrity of the adhesive tape. The exercise intervention between trials in both studies proved to have an effect on the restrictive properties of the adhesive ankle tape. Comparing these studies shows a significant difference in both static and dynamic testing when comparing self-adhesive tape to adhesive tape.

Given the lack of differences we found in peak eversion moment between tape conditions, other factors must underlie the differences found in peak inversion angle. One factor may be that prophylactic ankle taping is designed to primarily prevent inversion motion (Pederson et al., 1997). The "stirrup" aspect of a standard ankle tape pulls from the medial to the lateral side of the leg, essentially pulling the ankle into an everted state (Quackenbush, Barker, Stone Fury, & Behm, 2008). When landing from a vertical jump or depth drop, taping does not necessarily impede the eversion movement whether or not the structural support of the prophylactic tape has been compromised. Thus the lack of eversion restriction with ankle taping likely explains why eversion moment was similar between the control and the ankle taping conditions. Another possible explanation for the lack of a difference in eversion moment may be related to the landing technique used in the jump and drop tests. In both the maximal vertical jump test and depth drop subjects were asked to land on two separate force plates to obtain separate limb measurements. This technique prioritized the landing phase and likely resulted in less “natural” landing kinematics and kinetics. Having the subject cognitively prepare for landing ahead of time may have resulted in similar moment measurements. A study done by McNair tested the effects of instruction on vertical ground reaction forces (GRF) associated with landing from a vertical jump. His study showed that “instructions related to kinematics led to significantly greater decreases in peak vertical ground reaction forces (McNair, Prapavessis, & Callender, 2000).” He suggests that bringing a subject’s attention to external cues may lower vertical GRFs (McNair et al., 2000).

Vertical jump height performance was not compared in this study. Previous studies were able to determine that prophylactic ankle supports (both adhesive taping and bracing) did not impede vertical jump performance (Ambegaonkar et al., 2011; Hodgson et al., 2005). No current studies have measured vertical jump height for self-adhesive tape. During preliminary vertical jump testing, subjects were allowed to land however they were not given any instruction regarding landing. In contrast, during the experimental trials subjects were given specific instruction to land with each foot on separate force plate. After giving the subject the specific landing cues, vertical jump height appeared to decrease for the experimental trials as compared to the preliminary jump trials. Although maximum jump height was likely different in the experimental trials compared to the preliminary trials, it was likely similar between experimental tape conditions given that the directions for landing were the same.

One of the central factors in this study is the exercise program. The exercise regimen was made part of this study to determine if exercise plays a role in tape degradation. As previously proven, adhesive tape's structural restrictions are shown to diminish with exercise (Ambegaonkar et al., 2011; Purcell et al., 2009; Ricard et al., 2000; Riemann, Schmitz, Gale, & McCaw, 2002). Previous studies gave time recommendations ranging from ten to sixty minutes to achieve a period long enough to cause detrimental structural damage to the adhesive tape (Ambegaonkar et al., 2011; Cordova et al., 2000; Purcell et al., 2009). For this study, we chose a 15-minute time frame because it within the time frames reported from the previously mentioned studies and because we thought subjects were more likely to complete the study. An increased time of exercise may produce a greater pre to post exercise difference in peak inversion angle and peak eversion moment during the landing phase. The intensity of exercise is also a fundamental piece along with the timeframe. The RPE level of three was chosen based on a similar study done by Cordova (2000). In his study, it was noted that "moderate exercise" is all that is necessary for tape degradation (Cordova et al., 2000). Unfortunately, the RPE for each subject was one variable that was not fully controlled due to its subjective nature. One subject's RPE level of three could be completely different from that of another subject. This variability may have led to differences in the stresses applied to the prophylactic support during exercise, which could have produced different results in the study. Similar to the time we chose, the moderate level of exercise was also selected due to the hope of increasing subject adherence. The last aspect of exercise that played a key role is the exercise test itself. The modified Illinois Agility Test was chosen due in part to a similar study by Childs ran in 2007. The test showed promise due to the fact that it contained elements that stressed all motions of the ankle to a certain degree. Yet the stress placed on the ankle, in combination with the low intensity, may not have been enough to compromise the tape to create a noteworthy difference on ankle kinematics. Furthermore, the exercise did not include any jumping elements to directly stress the tape in the same way as our testing protocol. Incorporating a jumping component to the exercise could have further increased the stress to the prophylactic support, and perhaps created a different result.

Future Research

Based on the results of this study and others, future studies of the effectiveness of self-adherent tape are warranted. This study contained a low number of participants that could have been a factor in the limited amount of kinematic changes produced. A larger group of participants could help future studies find a greater significance between the prophylactic support types. In order to further investigate the effects that tape conditions and exercise have on lower body kinetics when landing from a vertical jump, future studies could focus on an expanded/more intense exercise regime. Although some differences were found in this study, increasing the pace and/or duration of exercise may yield greater results. A greater kinematic variability may have occurred had there been more subjects. Another area future studies could investigate is using a true maximum vertical jump. This study produced results with a controlled maximal vertical jump to land on separate plates that seemed to lower overall vertical jump height. A study with a true maximal vertical jump may generate greater ankle kinematic differences and a more realistic application. As Lai stated, lateral ankle sprains occurred when the ankle was in a plantar flexed and inverted position (Lai & Lee, 2015). He also went on to describe his findings in that an increased height created a higher risk of a landing mechanism with greater ankle plantar flexion and inversion angles (Lai & Lee, 2015). With an increase in that landing mechanism, there is a higher chance of an ankle sprain (Lai & Lee, 2015). The question on whether or not self-adherent tape will help prevent/treat an ankle injury better than standard adhesive tape is still not fully known. Lastly, future studies should look into the effect that self-adherent tape has on knee, hip, and lower back joint mechanics. As a result of increased restriction of ankle motion, kinematics of other joints may compensate in some way. Some studies have speculated that the unnatural constraint of ankle taping increases the risk of injuries to proximal joints such as the knee (Stoffel et al., 2010). Other joints that may see a kinematic effect from prophylactic ankle support could also include the hip and lower back. This study is a stepping-stone for further investigation of the effects self-adherent tape on full-body kinematics.

Conclusion/Implications

In conclusion, self-adherent tape showed promise as an alternative to standard adhesive tape in restricting peak ankle inversion. However, which is the superior tape could not be distinguished at this time. When comparing self-adhesive tape to adhesive tape, the difference in peak inversion angle remains the only advantage of self-adherent tape found by this study. Its restrictive properties throughout the duration of exercise could be beneficial for both prevention and treatment of ankle inversion injuries. Athletic trainers and athletes alike could both benefit from the usage of self-adherent tape in the athletic field. The nature of the tape shows promise for usage outside of the ankle as well. Other applications could include knee, wrist, and elbow tapings among others.

Author Contributions

Conceived and designed the experiments: Chris Gregoire, Justus Ortega, Shannon Childs. Performed the experiment: Chris Gregoire, Stephanie Chuml, Riann Thayer, Jazz Lewis, Ryan Matteri. Analyzed the data: Chris Gregoire, Justus Ortega. Wrote the paper: Chris Gregoire, Justus Ortega.

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("Active Ankle," 2016; "Athletic Training," 2015; Blickhan & Full, 1993; Bot & Van Mechelen, 1999; Burks, Bean, & Marcus, 1991; "Cohesive Bandages," 2015; "IvyRose Holistic Homepage," 2016; Linthorne, 2001; Winter, 1990)

APPENDICES

Appendix A: Participant Informed Consent

The Effects of Self-Adherent Taping on Peak Inversion Angle and Angular Torque Upon Landing During a Vertical Jump and a Depth Drop

Principal Investigator: Chris Gregoire, B.S.

(Approval Date:)

PARTICIPANT INFORMED CONSENT FORM

Please read the following material that explains this research study. Signing this form will indicate that you have been informed about the study and that you want to participate. We want you to understand what are you are being asked to do and what risks and benefits are associated with the study. This should help you decide whether or not you want to participate in this study.

You are being asked to participate in a research project conducted by Chris Gregoire under the supervision of Justus Ortega, Ph.D., Department of Kinesiology and Recreation Administration, 1 Harpst St., Arcata, CA, 95521. **Dr. Justus Ortega may be reached at (707) 826-4274 or jdo1@humboldt.edu to answer any questions or concerns.**

Project Description:

The purpose of this study is to examine the effectiveness of self-adherent tape in controlling peak inversion motion and angular torque compared to traditional cloth tape. Athletic tape is a commonly used application for helping prevent and treat ankle injuries. Some research gives credibility to the method of stabilization, however, there is also a lot of research questioning its reliability and effectiveness. Self-adherent tape may prove to be a better means of stabilizing the ankle against inversion. However, the effectiveness of self-adherent tape in reducing inversion motion and torque during landing remains unclear; especially in comparison to the traditional ankle stabilization modalities of traditional taping. You are being asked to be in this study because you are 18-25 years of age and in good health. Participation in this study is entirely your choice.

Procedure:

If you agree to take part in this study, you will be asked to come to the laboratory for three experimental sessions. There is no monetary compensation for participation in this study. All experimental sessions will take place in the HSU Biomechanics Lab and the Lumberjack Arena.

Orientation and Preliminary Jump Session (30 minutes)

- We will explain the study and what we will ask you to do.

- You will read the informed consent.
- We will answers any questions you may have.
- You will sign the informed consent form, if you agree to participate in the study.
- You will complete a medical history questionnaire
- You will perform 3 maximal vertical jumps as a base measurement
- Your inversion range of motion will be taken

Jump Sessions (about one hour thirty minutes)

- You will perform a set dynamic warm-up series
- We will apply an external ankle prophylactic (either self-adherent tape, cloth tape, or none at all)
- We will apply reflective ball markers onto your lower body
- You will perform 3 maximal vertical jumps and 3 depth drops
- You will perform a 15 minute bout of jogging in a set pattern
- We will reapply reflective ball markers
- You will perform 3 maximal vertical jumps and 3 depth drops once again

Participation in this study should take approximately five hours and five minutes total time. The total time commitment is broken up as follows; orientation (30 minutes), and experimental trials (1 hour and 30 minutes per day [3 days]).

A maximum of 30 participants will be invited to participate in this research study.

Risks and Discomforts:

There are some potential risks if you take part in this study. During both the vertical jumping tests, the depth drops, and the jogging, there is a small risk that you may injure yourself. In the case that you become injured or feel uncomfortable continuing, the test will be stopped. There is some risk of falling during the jumping and jogging sessions as well. There is also risk of musculoskeletal and/or ligamentous injury due to the explosive movements during the vertical jump test. During the experimental sessions there is a small risk that you might experience skin irritation when we remove adhesive reflective markers. However, we will be using hypoallergenic adhesive to minimize this risk. Moreover, the members of our research team that will be conducting this experiment are all CPR and first aid certified and will provide constant supervision as an additional safety precaution. Aside from these risks, none of the other procedures should cause you discomfort or injury.

Benefits:

The benefits to the subjects for participating in this study include: (a) knowledge of the new preventative and treatment tape options, (b) light exercise during exercise regimen.

Subject Payment:

You will not be paid for participation in this research study.

If you feel that you have been harmed while participating in this study, you should inform the faculty supervisor, Dr. Justus Ortega, (707) 826-4274 immediately. If you are injured, Humboldt State University will not be able to pay for your medical care. State law may limit Humboldt State University's legal responsibility if an injury happens because of this study.

Study Withdrawal:

You have the right to withdraw your consent or stop participating at any time. You have the right to refuse to answer any question(s) or participate in any procedure for any reason.

Confidentiality:

We will make every effort to maintain the privacy of your data. From the beginning of your participation, you will be given a unique identity code. This code will be used instead of your name for all documentation of your participation. We will keep your individual data and results confidential including computer files, paper files, and any personal information. In written or oral presentations of the results of this research, your identity and individual information will be kept confidential. After the project is complete, the materials associated with the project, including computer files, paper files, digital video files, and personal information will be secured in a locked cabinet in a locked office under the supervision of Dr. Justus Ortega for five years in case there is a need for future verification or reanalysis of the data. Upon completion of this informed consent form, you will receive a signed copy of the consent form.

Other than the research team, only regulatory agencies, such as the Humboldt State University Committee for the Protection of Human Subjects in Research may see your individual data as a part of routine audits.

Invitation for Questions:

If you have questions about this study, you should ask the researcher before you sign this consent form. **You may also contact Chris Gregoire, the Primary Investigator to answer any questions or concerns regarding the study at cmg454@humboldt.edu or (916) 524-6176.**

If you have any concerns with this study or questions about your rights as a participant, contact the Institutional Review Board for the Protection of Human Subjects at irb@humboldt.edu or (707) 826-5165.

Authorization:

I have read this paper about this study or it was read to me. I know the possible risks and benefits. I know that being in this study is voluntary. I know that I can withdraw at any time. I have received, on the date signed, a copy of this document containing 4 pages. I understand that the researcher will answer any questions that I may have concerning the investigation or procedures at any time. I also understand that my participation in this study is entirely voluntary and that I may decline to enter this study or may withdraw from it at any time without any penalty. I understand that the investigator may terminate my participation in the study at any time.

Name of Participant (printed) ____

Signature of Participant ___________________________ Date ______________.
(Also initial all previous pages of the consent form.)

For IRB Use Only

Appendix B: Medical History Form

Medical History
The personal health history is designed to assist the study by maintaining a safe atmosphere to each participant. Please write neatly and fill out form in ink only. Please answer truthfully, completely and provide dates and details to the best of your knowledge for each yes response. The information you provide is confidential. Prior to the start of study your medical history form will be revealed to make sure you are safe to take part in the study. If yes responses are not adequately explained, further interviewing will be necessary before medical clearance is granted.

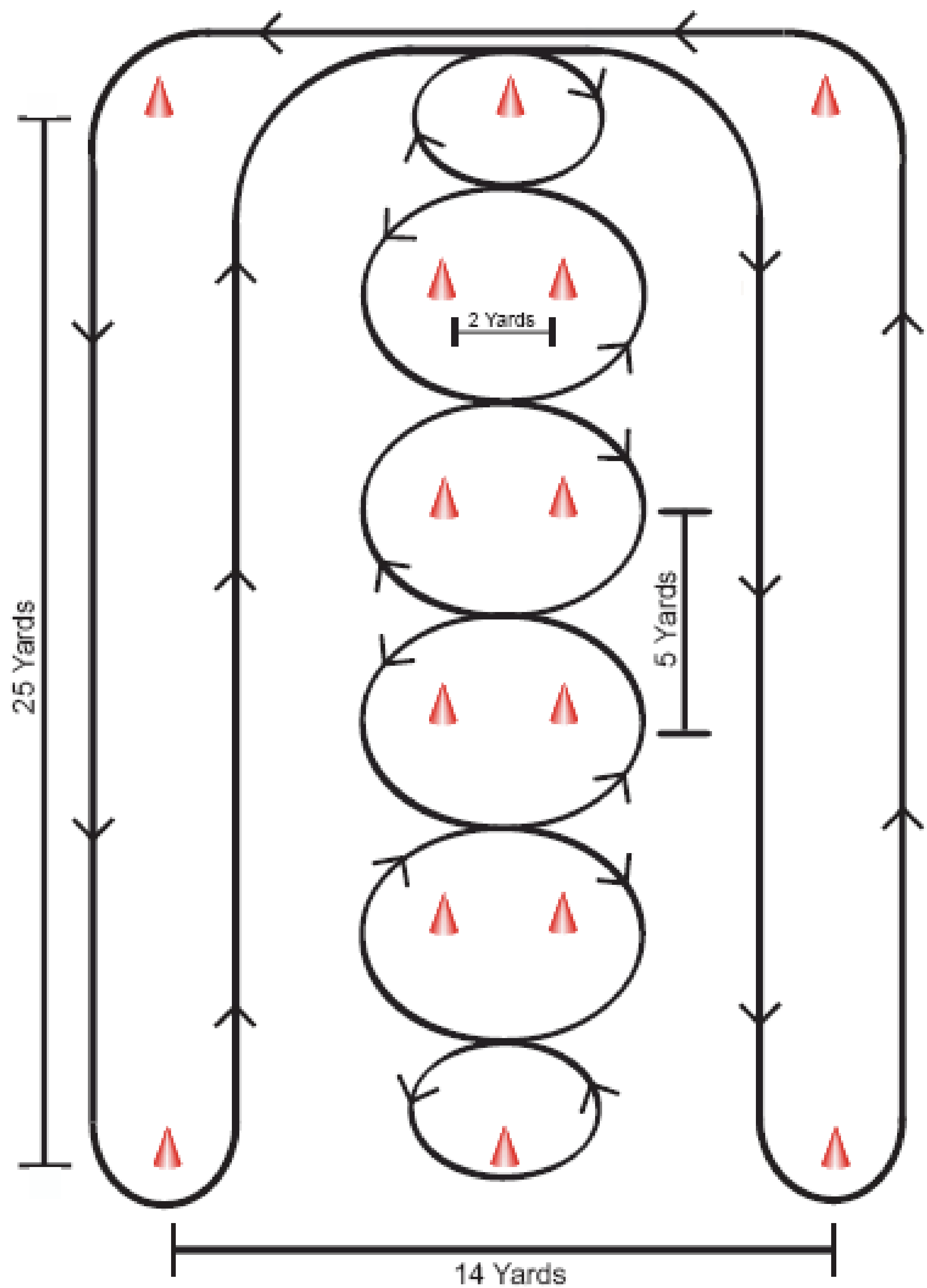
Please check the appropriate response for each question.

Item #:	**In the past 6 months, have you ever had or do you currently have:**	**Response:**	**Details (specific information, dates, brief explanations):**
1	Concussion/head injury?	Yes□No	Date of most recent? Currently have symptoms? Yes No
2	Fractured/broken bone?	Yes□No	If yes, when? If yes, what body part?
3	Injury to neck?	Yes□No	When? Diagnosis:
4	Injury to shoulder?	Yes□No	When? right left both Diagnosis:
5	Injury to elbow/wrist/hand?	Yes□No	When? right left both Diagnosis:
6	Injury to back/spine?	Yes□No	When? Diagnosis:
7	Injury to abdomen, chest or ribs?	Yes□No	When? Diagnosis:

8	Injury to hip/pelvis?	Yes□No	When? right left both Diagnosis:
9	Injury to knee?	Yes□No	When? right left both
10	Injury to ankle/foot/leg?	Yes□No	When? Right, Left, Both Diagnosis:
11	Injury to face/eye/nose?	Yes□No	When? Diagnosis:
12	Stress Fractures?	Yes□No	Body part:
14	Recent surgeries?	Yes□No	If yes, please explain:
15	Do you currently have an unhealed injury?	Yes□No	If yes, please explain:
16	Any other injuries, illnesses, or other health related issues not listed?	Yes□No	If yes, please explain:

Additional notes (please reference with item #, use back of page if necessary):

Appendix C: Modified Illinois Agility Test



Appendix D: Rated Perceived Exertion Scale

HOW HARD IS THE ACTIVITY?

0	Nothing at all
0.5	Just noticeable
1	Very light
2	Light
3	Moderate
4	Somewhat heavy
5	Heavy
6	
7	Very heavy
8	
9	
10	Very, very heavy
* *	Maximal