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Effects of External Ankle Support on Dynamic Movements: A Randomized Controlled Trial

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EFFECTS OF EXTERNAL ANKLE SUPPORT ON DYNAMIC MOVEMENTS: A RANDOMIZED CONTROLLED TRIAL

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This Scholarly Project, submitted by Danny Henderson, Brian O'Neal, Kevin Voss, and Bret Zowada is for partial fulfillment of the requirement for the Degree of Doctor of Physical Therapy from the University of North Dakota, has been read by the Advisor and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

(Graduate School Advisor)

(Chairperson of Physical Therapy)

PERMISSION

Title: Effects of External Ankle Support on Dynamic Movements: A Randomized Controlled Trial

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Degree: Doctor of Physical Therapy

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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ABSTRACT

Ankle sprains are one of the most common injuries among athletes and individuals that perform dynamic activities on a daily basis. A common treatment or prevention for ankle sprain is the use of external ankle support in the form of braces or tape. This study's purpose was to determine whether external ankle support influenced dynamic performance measures.

The study consisted of 15 males and 15 females totaling thirty participants with a mean age of 24.67 years old. Subjects were included if they were healthy and had no previous ankle injuries. Using the NeuroCom Balance Master 8.2, each subject performed two dynamic tests consisting of the Step Up and Over (SUO) and the Forward Lunge (FL) test. Each test was performed with the subject wearing ankle tape, an ankle brace, and no external support in addition to an athletic shoe on the right lower extremity.

Forward lunge results revealed that lunge distances were highest with ankle tape but significant differences were seen only between the taping group and the bracing group. Movement time in the SUO test was shortest in the control group with significance achieved between the control group and the taping group. A significant difference was also demonstrated in this maneuver in impact index. No other significant differences were found between groups.

In conclusion, these results indicate that the use of external ankle support for protection influences dynamic performance activities, some negatively, others positively, and extension may ultimately have an effect on more intense activities, such as cutting, jumping, changing direction, and other dynamic functional movements. In addition, the use of external support may also subject the ankle, knee, or hip to abnormal forms of stress when impacting the surface during these activities, which in turn may predispose these joints to injury or other problems.

CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

Incidence of Ankle Sprains

One of the most common injuries for today's athlete is the ankle sprain. In order for a ankle injury to be classified as a sprain, injury has to result to the ligaments of the foot and ankle; a fracture of the bone cannot be present.[1] The demand put on the ankle joints frequently changes in relationship to the direction of body movement, with rapid acceleration, deceleration, and torsion forces all accumulating at the ankle joints. Whether the sprain is the cause of excessive eversion or inversion or just plain instability of the talocrural joint, ankle sprains occur on a daily basis, accounting for approximately 25 000 sprains per day and 9 million per year in the United States alone.[2,3] Acute ankle sprains, by far, account for the majority of all ankle injuries, resulting in roughly 85% of all ankle injuries of recreational and competitive athletes.[4]

Secondary to different methods of quantifying risk, it is very difficult to compare relative risks for ankle sprain injury across sports or profession. Even with this amount of difficulty, three important risk factors are usually involved in leading to a higher incidence of ankle sprains: the sport or work requirements of an individual at risk, a previous history of ankle sprains,[5] and dorsiflexion range of motion.[6]

There have been numerous studies done on ankle sprain incidence in sports, with researchers looking at multiple risk factors, indicators, predictors and prevention techniques. In 2007, Hootman et al[7] reviewed 16 years of National Collegiate Athletic Association (NCAA) injury surveillance data for men's and women's sports to identify potential areas for injury prevention initiatives. They looked at 15 different collegiate sports including football, basketball, ice hockey, volleyball, and soccer. From the result of the study, more than 50% of all injuries were to the lower extremity. Ankle ligament sprains were the most common injury over all sports, accounting for 15% of all reported injuries.[7]

Fong et al[8] reported that for ankle injuries in terms of incidence per 1000 person-hours, rugby had the highest general incidence (4.20), followed by soccer (2.52), volleyball (1.99), handball (1.59), and basketball (1.00). During games, the incidence was highest in soccer (11.68), followed by Australian football (4.86), and soccer (4.59). In terms of incidence per 1000 person-year, field hockey showed the highest incidence rate (1000.00), followed by rugby (233.40), basketball (173.50), dance (155.40), and American football (60.60). In terms of incidence per 1000 person-seasons, soccer showed the highest incidence in general (1200.00), while Australian football showed the highest incidence in competitive situations (111.10).

Although sports are not the sole proprietor of ankle sprains, the professional career one has can result in exposure the risks of experiencing an ankle sprain. Occupations involving sudden position changes, uneven surfaces, and pivoting activities have a definite increase on the likelihood of injury. The military, specifically the airborne division, is one such career in which ankle sprains are frequent, with ankle injuries account for roughly 15% to 60% of all injuries sustained from parachuting.[9]

As for differentiating between an increased risk between the sexes, there is limited research and inconclusive results. Sex differences in lower extremity alignment indicate that females, on average, have greater anterior pelvic tilt, thigh internal rotation, knee valgus, and genu recurvatum but these differences between sexes were not accompanied by differences in the lower leg, ankle, or foot.[10] Wilkerson et al[11] reported a statistically significant difference in ligament laxity of the lateral ankle, with laxity being greater in females than males. Beynnon et al[12] concluded that the risk of suffering an ankle sprain was higher for women than for men, but the difference was not statistically significant.

Anatomy of the Ankle Joint

The ankle joint consists of two main joints, the talocrural joint and the subtalar joint, and may also include the distal tibiofibular joint. The true ankle joint, the talocrural joint, is the type of joint which is referred to as a hinge joint. This allows for plantarflexion and dorsiflexion of the foot. The joint itself consists of the distal tibia on the medial side, the distal fibula on the lateral side and the talus which sits inferior to the aforementioned bones.

Located just inferior to the true ankle joint sits the subtalar joint, which is a planar joint, allowing for supination, pronation, eversion and inversion of the foot. The talus superiorly and the calcaneus inferiorly comprise the subtalar joint. The talocrural joint is supported by three separate ligaments (anterior and posterior talofibular and calcaneofibular) on the lateral side with one ligament (deltoid) consisting of four sections (tibionavicular, tibiocalcaneal, and anterior and posterior tibiotalar) supporting the medial side. It is here, at the talocrural joint, where the majority of ankle sprains occur, with 85% being caused by inversion trauma.[13]

Muscles that provide additional stability and support to these joints include the fibularis longus and brevis, the gastrocnemius and soleus, comprising the Achilles tendon, the tibialis anterior, extensor digitorum longus, extensor hallicus longus, flexor digitorum longus, and flexor hallicus longus. Postural control from these muscles include inversion, eversion, plantar flexion, and dorsiflexion.

Effects of Prophylaxis

The majority of treatments used for the prevention of ankle injuries are typically some form of supportive device, being bracing, taping, or a combination of both. There have been many research attempts to discover the efficacy of external ankle support, for example, in a 2001 Cochrane Database system review of 14 randomized trials with 8297 patients, Handoll et al[14] concluded that ankle supports reduce ankle sprains and reinjury. There have also been many attempts focused on finding the impact that external devices have on performance, and previous results have concluded that external ankle support doesn't enhance or restrict motor performance.[3,4,15-24] Future research needs to be focused on the effects of external ankle devices during dynamic exercise.

Other research studies have questioned the theory that external ankle support may not add more ankle stability compared with no external devices. A study done by Rosenbaum et al[17] looked at the influence of ankle braces in a sports-related agility course. This study found significant differences between the types (rigid, semirigid, soft) of braces tested on the course. However, these were subjective differences that were related to comfort and handling but not performance. There were no significant differences found between the types of braces when it came to performance of the agility course.[17] Semirigid and laced ankle braces have significantly reduced the incidence of initial and recurrent ankle sprain injuries in athletic and military samples.[9] With a small amount of exceptions, these braces do not appear to influence functional performance unfavorably. The prophylactic use of semirigid ankle braces appears practical to reduce the incidence of initial and recurrent ankle sprain injuries for individuals who participate in activities that have the highest risk for these injuries.

Riemann et al[21] looked at the effects of ankle bracing and taping on vertical ground reaction forces during a drop off landing. They concluded that ankle taping and bracing decrease the time to reach peak impact forces. These results indicate that during dynamic activities with support, the musculoskeletal structures of the body may be subjected to loads within shorter time periods. Whether these effects are detrimental over time remains speculative at this point and requires further research.[22]

Throughout the numerous studies conducted on ankle sprains, performance, and prevention of injuries, there appears to be no concrete evidence suggesting that one type of prophylactic is better than another in prevention of this common occurrence. Metcalfe et al[24] compared three types of prophylactic supports (Moleskin tape, linen tape, lace-up brace) and concluded that if near optimal performance and sufficient ankle/subtalar restriction is preferred, there does not appear to be any benefit in choosing one support type over the other.

Static vs Dynamic Stability and ROM

As mentioned above our study concentrated on dynamic movements rather than static postural control, since it is during these types of activities that most athletic injuries occur. Ankle sprains are the most common injury in the sport of basketball, involving jumping and cutting movements as demonstrated by Ide et al.[25] Meana et al[26] showed that dynamic and static range of motion were significantly different for supination and plantar flexion using high-speed 3D photogrammetry prior to and after training sessions in 15 young men with no prior ankle injuries. They revealed that ankle taping was effective in restricting maximal static range of motion; however the effectiveness decreased after 30 minutes of training.[26] This demonstrates the need to assess the effects of taping and bracing during dynamic movements such as we are, due to the fact that there are differences between static and dynamic ROM.

In a study by Ross and Guskiewicz[27] they revealed that there was a significant difference in dynamic postural stability in individuals with functionally stable and unstable ankles. It took subjects with functionally unstable ankles significantly longer to stabilize on one foot after a jump landing test in both the anterior/posterior and medial/lateral directions. However, there were no differences in postural stability with just the static single leg stance.[27] Once again it would be important to look at what effects ankle prophylaxis would have on such dynamic tests.

Using the computerized force plate system of the Balance Master we were able to record the amount of body weight percentage generated through each lower extremity that would be calculated as the impact index. Hrysomallis et al[28] showed that the magnitude of the maximum center of pressure was significantly greater during a dynamic stepping balance test when compared to a static single leg stance test. The center of pressure that Hrysomallis et al[28] examined is closely related to the impact index that our study concentrated on when looking at the effects of ankle tape and bracing during our dynamic tests.

Ankle Taping vs Bracing

Ankle taping and bracing have been forms of prevention and treatment for athletes who are at risk or have experienced an ankle injury. There has been a lot of controversy on whether or not ankle prophylactics impede an athlete's ability to perform at an original level of competition. In addition, there is continued controversy on which type of ankle prophylactic device is better, adhesive taping or ankle bracing. Our predictions for this study were that wearing either ankle tape or the brace will decrease and limit the subject's ability when compared to not wearing an ankle prophylactic device. MacKean et al[29] revealed that ankle support did in fact impair the overall performance of female basketball players during four performance tests. They found that the athlete's vertical jump was decreased when wearing ankle tape compared to no tape, and oxygen consumption and energy expenditure were higher when the subjects wore an Aircast (Air-cast, Inc., Summit, NJ) as compared with tape (Dr. Scholl's double seal 1½ in adhesive).

In a study done by Paris,[16] 18 elite soccer players performed selected tests of speed, agility, balance, and vertical jumping under the conditions of several types of ankle braces and adhesive taping, which was then compared to a control group with no taping or prophylactic device. This study found that the vertical jump scores were significantly reduced when using the New Cross Brace but not when using the tape or other braces.

Verbrugge[29] performed a study that compared the performance of 26 male athletes either wearing an Air-Stirrup brace or adhesive tape against a control group who had no supportive device on. Contradicting the previous two articles, these data suggest that using an Air-Stirrup brace or standard adhesive taping has no substantial effect on sprinting speed, agility, or vertical jumping ability.

Research has mixed results on whether ankle taping or bracing is better for athletes to perform at their best abilities. Our study like others will compare the effects of ankle taping and bracing versus no support during dynamic stepping and lunging. To some degree it may be the athlete's preference to what is felt to be the most comfortable prophylactic and what gives them the best support when actually selecting a supportive device for the ankle.

CHAPTER 2

METHODS

Setting

All research was conducted within the University of North Dakota's Physical Therapy Department in research room 2541. The research room is located in an area with minimal distractions that maximizes subjects' privacy and concentration. During the testing session only the test subject and the four researchers were present in the research room. Upon completion of testing, subjects' results were stored in a locked file cabinet.

Participants

Thirty subjects (15 male and 15 female), were college students ranging between the ages of 21 and 28 years old with no recent history of ankle trauma (injury within the previous 2 weeks) or past medical history of balance disorders. Subjects were also excluded from this study if they were allergic to tape adhesive or prewrap, and/or didn't possess adequate athletic shoes.

NeuroCom® Balance Master 8.2

The NeuroCom Balance Master 8.2 (NeuroCom International, Inc; Clackamas, OR) (see figure 1) was utilized to asses the influence of ankle taping, ankle bracing or no external support on performing a functional skill (Forward Lunge [FL] and Step Up/Over [SUO]). This device is commonly utilized by physical therapists in the assessment of postural control, balance, and functional skills.[31,32] The NeuroCom Balance Master is a computerized device that gathers information on postural stability and weight transference through force plates on which the subjects performed both the Step Up/Over and the Forward Lunge tests. Lebib et al [31] found that the NeuroCom Balance Master can not only estimate postural balance but also can account for the vestibular system and reproduce physiological conditions of daily life. However, the tests performed in this study were more dynamic activities that an athlete would perform rather than regular activities of daily living. The NeuroCom Balance Master provides a means to compile clinical databases for research. It is a device with computer software that receives input from two force plates that measure ground reaction forces. The computer receives the force measurements from the dual force plates and analyzes the information, generating a screen display and/or a printed report. The data and results are stored on the hard disk of the computer. A Balance Master also has a computer monitor, which provides a demonstration of desired functional activity and signals (both visual and auditory) to direct the subject to initiate and terminate activity.[33,34]

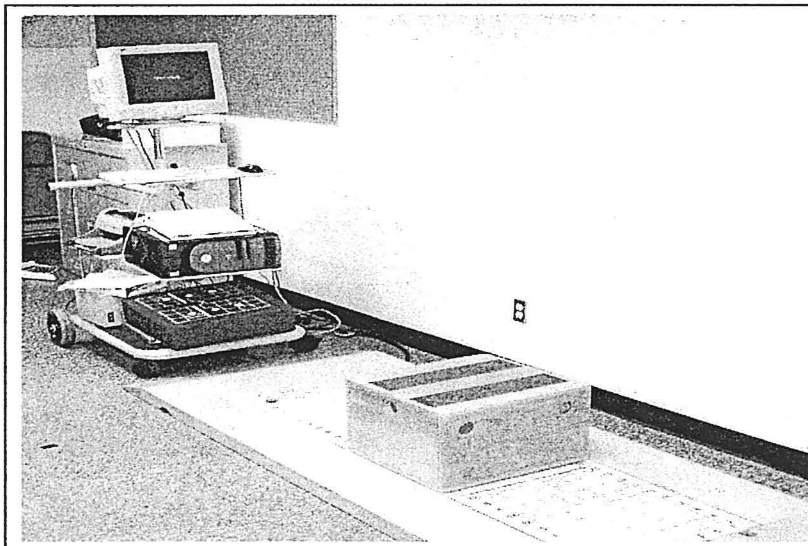

Figure 1. NeuroCom® Balance Master 8.2

Procedure

Each subject performed two functional dynamic tests with varying conditions (ankle tape, ankle brace, and no external support). The functional tests performed were the Forward Lunge (FL) and Step UP/Over (SUO). Prior to performing the FL one researcher instructed the subject on proper foot placement on the force plate. This foot alignment consisted of placing the lateral aspect of the subject's foot along the lateral line and the patient's heel along the back line of the force plates (see Figures 2 & 3). Prior to the start of the test the subject viewed a visual demonstration of the desired movement via the computer monitor. The FL required the subject to lunge forward with one leg as far and as fast as possible and then return to the starting position in the same manner. Each subject performed this test three times on each leg for a total of six trials. This test was done under each condition of external ankle support. The parameters measured were mean distance, mean impact index, and mean contact time. Mean distance is the average length of the forward step, expressed by the percent of body height. Because subjects are asked to lunge as far and as fast as possible, higher scores are considered to be a better functional outcome. Low mean distance scores could possibly be due to joint restriction, weakness, and/or instability. Mean impact index is the average maximum force transmitted through the lunge leg as it lands on the force plate surface, expressed as a percent of body weight. The lunge leg must be able to switch from concentric control to eccentric control as the center of gravity passes over the foot. The amount of impact force transmitted through the lunge leg as it lands is an indication of eccentric control. Low scores are desired and represent good eccentric control: high scores represent diminished eccentric control. Poor eccentric control could be due to weakness, joint laxity, and/or sensory loss. Mean contact time is the average amount of time the lunge foot is in contact with the surface during the forward step, expressed in seconds. Because the subject is asked to lunge as far and as fast as possible, low scores are preferred and high scores indicate lower function. Longer contact times may be a result of an eccentric deficit, concentric deficit, sensory loss, lack of coordination, and/or imbalance (speed sacrificed for stability).[34]

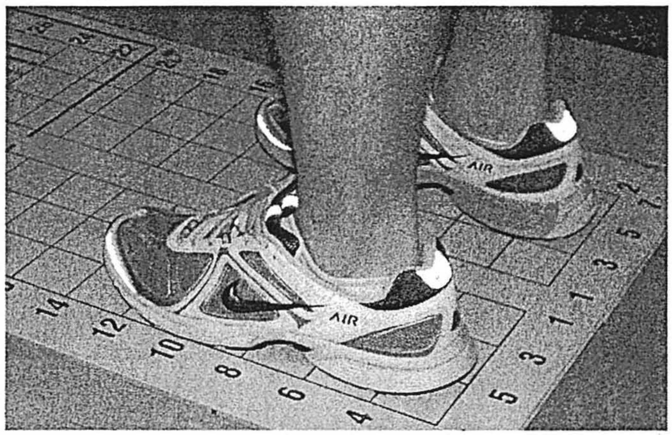

Figure 2. FL Foot Placement (Lateral View)

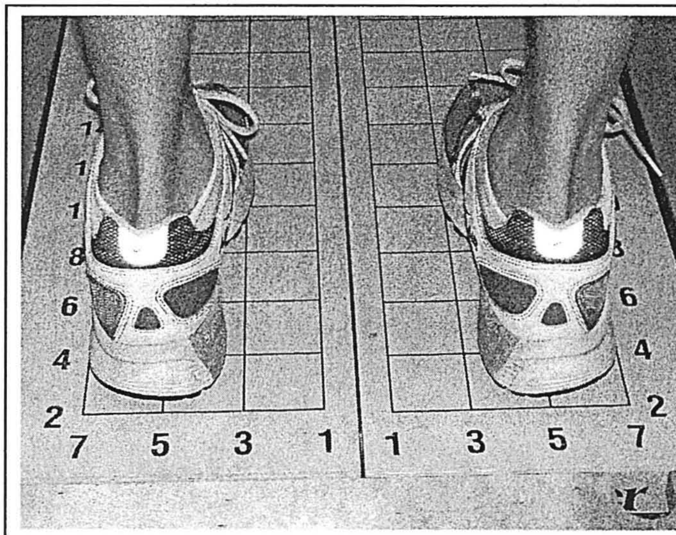

Figure 3. FL Foot Placement (Posterior View)

Prior to performing the SUO the subject was instructed in proper foot alignment by the designated researcher. This foot alignment consisted of aligning the feet shoulder width apart and providing enough distance away from the box for foot clearance (see Figure 4). Prior to the start of the test the subject viewed a visual demonstration of the desired movement via the computer monitor. The SUO required the subject to step on top of a 12-in box with one foot and then to step down and on to the force plate with the opposite foot contacting first, (without contacting the 12-in box). Subjects performed this test three times with each leg leading for a total of six trials. Each test was performed with each condition of external support. The parameters measured were mean movement time and mean impact index (impact force). Mean movement time is the average amount of time to complete the SUO, expressed in seconds. Low scores have higher functional value. Slower movement times may be due to joint restriction, decreased balance, and/or discomfort. Mean impact index is the average force transmitted through the lagging leg as it lands on the force plate, expressed as a percent of body weight. The step up leg must switch from concentric control to eccentric control. The amount of force generated is an indication of eccentric control. Low scores may be a result of weakness, joint laxity, sensory loss, and/or pain.[34]

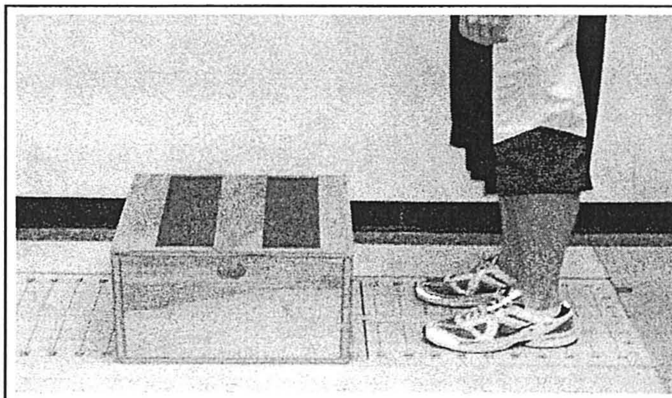

Figure 4. SUO Foot Placement

Prior to testing, each individual subject was required to sign a consent form which provided information regarding the purpose, testing procedures, and risks involved in the study. The consent form also included subject confidentiality and the right to terminate participation at anytime during the study. After signing the consent form subjects were asked to randomly select from 6 cards lying face down on the table. These cards were numbered 1 to 6, displaying the following conditions:

1. Ankle Brace-FL Test
2. Ankle Brace-SUO Test
3. Ankle Tape-FL Test
4. Ankle Tape-SUO Test
5. Shoe only (control)-FL Test
6. Shoe Only (control)-SUO

Whichever card was selected, the subject performed both functional tests under that condition. In other words if the subject picked a card/condition in which the ankle was taped (Cards 3 and 4), it necessitated the performance of both the FL and SUO test with the ankle taped. Therefore, both cards 3 and 4 with ankle taped conditions would be removed, leaving four remaining cards. After completing the functional test under the first selected condition the subject randomly selected from the four remaining cards. Upon completing the functional tests under the second condition a selection was made from the final two remaining cards. External support was applied to the right ankle only.

Ankle Bracing

Selecting the appropriate brace involved the following factors. The brace that was chosen was one that allowed ankle sagittal plane movement (plantar flexion/dorsiflexion), while restricting frontal plane movements (inversion/eversion). The brace also needed to be able to conform to a right ankle.

The brace that was used was the T2 Active Ankle® (Active Ankle Systems, Inc., Jeffersonville, IN) (see figure 5). This brace "features a durable, quick-fitting single strap system that is adjustable for both high and low-top shoes." There were three sizes available, small, medium and large to accommodate different shapes and sizes of ankles. For consistency and reliability the same researcher assisted in fitting the subjects with the proper-sized brace and followed the instructions provided by Active Ankle fitting instructions.[35]

Braces were applied to the right foot only. After selection of the proper-sized brace, the brace was inserted into the subject's shoe. If the subject had an orthotic or insert, the floor of the brace was inserted underneath the orthotic or insert. If it was a typical shoe, the brace was applied directly into the subject's shoe. The subject then placed the foot into the shoe and was instructed the subject to stand. The researcher then fitted the brace according to Active Ankle instructions.

Figure 5. T2 Active Ankle Brace®

Ankle Taping

For ankle taping purposes the closed Gibney method (see figures 6 & 7) was utilized.[36] Each participant was taped by a NATABOC certified athletic trainer (ATC) with six years of taping experience at the high school, collegiate, and professional levels. Each subject sat in the long sitting position on the treatment table/plinth with the right ankle off the edge. Each subject was instructed to keep the ankle in the neutral position (0° plantar flexion/dorsiflexion and 0° inversion/eversion) throughout the entire taping procedure. Next, the patient's right ankle was covered with prewrap to protect the integrity of the skin. One and a half inch-width Mueller Tape® (Mueller Sports Medicine Inc, Prairie du Sac, WI) was used for ankle taping. First, three anchor strips were applied to the ankle, two at the base of calf and one distal to the base of the 5th metatarsal. Next, three stirrups were applied, running from medial to lateral so as to encourage eversion over inversion. Each stirrup started from the medial lower leg at the level of the lower proximal anchors and continued under the arch of the foot. As the stirrup was pulled laterally, drawing the foot into slight eversion, increased tension was added. The stirrup ended at the lateral leg anchor. Tape was then applied circumferentially, serially from the lower leg anchors to the talocrural joint. Following this, 2 medial heel locks and 2 lateral heel locks were alternated as they were applied. The initial heel lock started on the medial side of the ankle joint, proximal to the medial malleolus. The strip crossed the front of the ankle joint and continued down the lateral side of the foot. The strip was brought across the plantar surface of the foot and continued posteriorly to the medial malleolus. The second heel lock was applied in the same fashion but begun on the lateral aspect of the ankle joint. Finally, a single strip of tape was used around the arch area to close off loose ends of all the heel locks. For this taping method we used a total of 11 strips of athletic tape for each subject.[37]

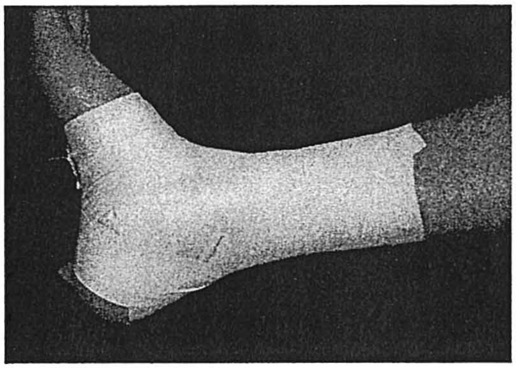

Figure 6. Closed Gibney (Medial View)

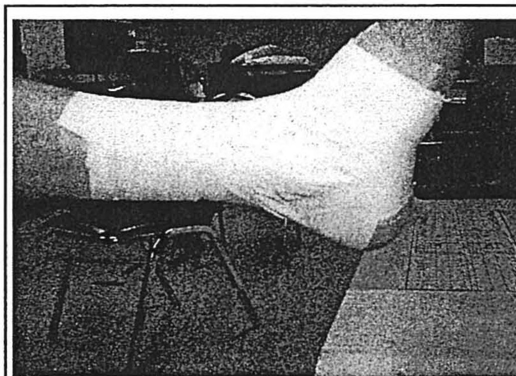

Figure 7. Closed Gibney (Lateral View)

Data Analysis

The repeated measure analysis of variance (RM ANOVA) was used to investigate the difference among the different external ankle support conditions of the control condition, ankle bracing, and ankle taping on the parameters assessed for each test (FL and SUO). Results of each parameter were expressed by the mean, standard deviations, F value, degrees of freedom, significant levels, eta squared, and power. An alpha level of $P<.05$ was the standard for statistical significance. The SPSS-11.0.1 software (Lead Technologies Inc, Chicago, IL) was used to analyze the data.

CHAPTER 3

RESULTS

Results of FL test can be found in Tables 1 and 3. Results demonstrate that the taping group had the greatest lunge distance at 50.93 (% BH) followed by the group with no external device at 49.73 (% BH) and the bracing group at 49.03 (% BH). There was a significant difference demonstrated only between the bracing and taping groups (p=.039). There was no significant difference between the three groups with respect to mean contact time and mean impact index during the FL test.

Results for the SUO test can be found in Tables 2 and 3. There was a significant difference in movement time between the control group whose time was 1.35 seconds and the taping group at 1.46 seconds (p=.039). There was no significant difference found between the taping and bracing groups or the control and bracing groups. There was also a significant difference in impact index between the control group (55.07 % BW) and the taping group (58.97 % BW) (p=0.008). There was no significant difference found between the control and bracing groups or the bracing and taping groups.

Table 1: Forward Lunge Distance, Contact Time and Impact Index Descriptive Statistics				
Condition	**Test**	**N**	**Mean**	**Standard Deviation**
Shoe Alone (% BH)	Lunge Distance	30	49.73	5.75
Brace (% BH)	Lunge Distance	30	49.03*	5.70
Tape (% BH)	Lunge Distance	30	50.93*	5.47
Shoe Alone (sec)	Contact Time	30	0.82	0.15
Brace (sec)	Contact Time	30	0.83	0.16
Tape (sec	Contact Time	30	0.86	0.18
Shoe Alone (% BW)	Impact Index	30	31.93	10.04
Brace (% BW)	Impact Index	30	30.97	8.86
Tape (% BW)	Impact Index	30	30.67	8.53

Percent Body Height (% BH), Seconds (sec), Percent Body Weight (% BW)
*Significant differences in lunge distance were found between the tape and bracing groups ($p<0.05$)

Table 2: Step Up/Over Time and Impact Index Descriptive Statistics				
Condition	**Test**	**n**	**Mean**	**Standard Deviation**
Shoe Alone (sec)	Movement Time	30	1.35*	0.2
Brace (sec)	Movement Time	30	1.35	0.16
Tape (sec)	Movement Time	30	1.45*	0.27
Shoe Alone (% BW)	Impact Index	30	55.07*	15.67
Brace (% BW)	Impact Index	30	55.07	17.66
Tape (% BW)	Impact Index	30	58.97*	15.54

Seconds (sec), Percent Body Weight (% BW)
*Significant differences in movement time and impact index were found between the control and taping groups ($p<0.05$)

Table 3: Forward Lunge and Step Up/Over Statistical Analysis					
Statistically Significant Tests	**F Value**	**DF**	**Significant Level**	**Eta^2**	**Power**
Forward Lunge: Mean Distance (%BH) Tape vs. Brace vs. Control	4.62	2, 58	0.014	0.137	0.759
Step Up/Over: Movement Time (sec) Tape vs. Brace vs. Control	4.07	2, 58	0.022	0.123	0.701
Step Up/Over: Impact Index (%BW) Tape vs. Brace vs. Control	4.28	2, 58	0.018	0.129	0.725
*Percent Body Height (%BH), Seconds (sec), Percent Body Weight (%BW)					

CHAPTER 4

DISCUSSION

The purpose of this study was to investigate the effects of external ankle support on dynamic movements. The first dynamic motion analyzed was the Forward Lunge test. We looked at the contact time of the forward lunge (left foot forward) and we anticipated that the contact time would increase with more restriction of right ankle motion. Therefore, we assumed that the taping group would have the most restriction and the control group the least, resulting in the taping group having the longest contact time and the control group having the shortest contact time. Our results confirmed our hypothesis. The taping group had the longest contact time (0.86 seconds), followed by the brace group (0.83 seconds), and finally the control group (0.82 seconds); however the results weren't significantly different. Impact index was also assessed during the forward lunge with the left foot forward. We hypothesized that the taping group would have the lowest impact force followed by the bracing and control groups respectively. Again our results supported our belief. The taping group had the lowest impact (30.67 %BW), followed by the bracing group (30.97 %BW), and the control group with the highest impact index (31.93 %BW). Nevertheless these results were not significant either.

Prior to testing we assumed that the lunge distance would decrease with a more restrictive external ankle device. According to You et al,[38] "circumferential ankle pressure in the form of bracing and taping increases active stiffness in the ankle" thus restricting motion. Therefore we hypothesized the tape would be the most joint restricting external ankle support followed by the brace, with decreased lunge distances taped decreased more than braced. We based this assumption on the fact that a requirement for sufficient lunge distance is adequate ankle range of motion at the hind leg's (right ankle) talocrural joint, which permits plantarflexion and dorsiflexion. Limitation in dorsiflexion should translate into a decreased forward lunge distance. The results of our study showed the taping group had the greatest lunge distance followed by the control group and then the bracing group. The results from this test conflicted with what we hypothesized. We have no other explanation for the taping group having the greatest lunge distance other then psychological factors coming into play. Perhaps the subjects felt more secure with taping, resulting in better performance in the forward lunge. Another explanation of this finding is that all subjects may have been taped in slight dorsiflexion thus permitting an easier maximal lunge distance. A possible justification for the bracing group having the smallest lunge distance could be that the brace has the most restriction at the talocrural joint.

The second dynamic test that we administered was the Step Up/Over. One parameter that we chose to analyze was movement time. We hypothesized that the tape would have the slowest movement time and the control group would have the fastest movement time because we believe these two conditions have the most and least restriction respectively. According to Cordova et al, [19] "braces and the traditional adhesive application do restrict foot and ankle motion that are necessary to propel the body at adequate speeds." Our results supported our hypothesis. The taping group had the slowest movement time (1.46 seconds) followed by the bracing group (1.37 seconds), and the control group (1.35 seconds) had the fastest movement time; however, significant differences were only found between the taping group and the control group. Another parameter that we evaluated was impact index performing the Step Up/Over of the left foot as it steps down (off the box) and contacts the force plate. We assumed that the tape would have the smallest impact index based on findings by Sacco et al,[39] because we felt the taping would provide more restriction of the right ankle, resulting in a deceleration in the decent of the left foot. We felt that the control group would have the largest impact index, because there is no external restriction on the right ankle, allowing the left foot to strike the force plate more forcefully. Our results were opposite from what we had expected and significantly different between the control and the taping groups. The control group had the lowest impact index (55.07 %BW), followed by the bracing group (56.07 %BW), and the taping group had the largest impact index (58.97 %BW). We have no explanation for these opposing results; on the other hand proprioception may be affected at the ankle due to the contact of the tape and/or brace. Perhaps more research is needed.

Based on our findings the selection of external ankle support may have an effect on performance. Our results indicate that tape may negatively impact performance by significantly increasing performance time (SUO movement time) and not providing adequate joint restriction (SUO impact index and FL lunge distance) when compared with no external support. Bracing may be an athletes best option for an external ankle device because it provides adequate ankle restriction without negatively affecting performance (movement time) or movement control (impact index). Bracing may also be the best choice because it doesn't lose it's restrictive properties as does tape.[25]

Limitations

There are several limitations that could improve the results for future studies. The following considerations could have negatively impacted our findings.

We had a sample size of 30 college-aged subjects. Although, 30 subjects is the typical goal for sample size, a large sample size varying in age may be a better representation of the normal population. A larger sample size also increases the power and significance of the results.

Another potential limitation of this study could have been not providing an agility activity prior to testing. Athletes typically warm up prior to activity. This activity can have an affect on the restrictive capabilities of the tape and brace as well as fatigue the surrounding ankle musculature which may have affected performance. Future studies should take this into consideration and include an agility component prior to testing.

Incorporating subjects who have never experienced having their ankle taped could have affected our results. We visually observed an obvious change in movement pattern in both the FL and SUO that the subjects attributed to discomfort from ankle taping. These subjects reported never being taped in the past. Future studies could tape subjects the week prior to testing to allow the subject to gain familiarity of ankle taping.

CHAPTER 5

CONCLUSION

This study found significant differences between the three ankle devices in regards to forward lunge distance with the bracing having the least distance. Our results revealed that there was no significant difference in movement time when comparing the bracing group to the other two conditions. These results would suggest that the brace both provides restriction/support without negatively impacting movement or performance. Therefore we conclude that a brace would be the best option for external ankle support when involving movement patterns that resemble dynamic skills used in this project.

APPENDICES

Appendix A

Informed Consent Document

Title of Research:

Effects of external ankle support on balance following dynamic movement tests: A randomized control research study.

Researchers:

Advisor: Mark Romanick
Student Researchers: Danny Henderson, Brian O'Neal, Kevin Voss, and Bret Zowada

Procedures:

You are invited to participate in this controlled research study conducted by Mark Romanick and above mentioned researchers. The purpose of this study is to determine if there is a significant difference in ankle stability using bracing, taping or no external support on the ankle during dynamic movements performed on the stationary Balance Master force plate. You will be completing two dynamic tests including the 1) Forward Lunge and the 2) Step Up and Over with your ankle taped, braced and with no external support for each test.

The Forward Lunge test is performed by standing with both feet together and shoulder width apart, followed by lunging forward leading with one lower extremity and then quickly returning to the starting position. You will try and lunge as far forward and as quickly as possible as your balance will allow. The Step Up and Over test is started by standing still with feet together and shoulder width apart, followed by stepping up onto a 12 inch box with your leading foot and leg and then stepping over the box with your opposite foot and leg, back onto the force plate to a stand still position. Both tests will be completed under all three above mentioned conditions, and should be completed in a total of one hour. You will only need to be seen for that testing day. There will be no costs to you as a subject nor will you be paid for participating.

Your participation is voluntary. You may choose not to participate or you may discontinue your participation at any time, and your decision whether or not to participate will not affect your current or future relations with the University of North Dakota or the Department of Physical Therapy here at UND.

Risks and Discomforts:

Possible risks may include accidental loss of balance during testing procedures. Other possible discomforts may include skin irritation due to athletic ankle tape and/or bracing. There will be a spotter near the Balance Master to help prevent any accidental falls. In the event that this research activity results in an injury, treatment will be available including first aid, emergency treatment and follow-up care such as assisting in referrals to appropriate medical facilities as needed. Payment for any such treatment is to be provided by you or your third-party payer. No funds have been set aside to compensate you in the event of injury. Also, the study staff cannot be responsible if you knowingly and willingly disregard the directions they give you.

Confidentiality:

Information obtained about the subject for this study will be kept private to the extent allowed by law. All subject information and consent forms will be stored in separate locked filing cabinets in a locked room with in the UND Physical Therapy Department. The advisor and all researchers will have access to all subject data.

Contacts and Questions:

You may ask any questions you have now. If you later have questions, concerns, or complaints about the research, please contact Mark Romanick at 701-777-2831 during the day (8:00 am—4:00 pm) or Bret Zowada at 307-340-0755 after hours. If you have questions regarding your rights as a research subject, or if you have any concerns or complaints about the research, you may contact the University of North Dakota Institutional Review Board at (701) 777-4279. Please call this number if you cannot reach research staff, or you wish to talk with someone else.

Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

______________________________ ______

Signature of Subject Date

______________________________ ______

Signature of Investigator Date

Subject ID #:_______

Appendix B

CONSENT FOR USE OF PICTURE

I, Bret Zowada, herby give permission the use of my photograph for use of this Scholar Project, IRB # 200705-357.

Bret Zowada
(Signature)

12-13-07
(Date)

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