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The Effects of Taping versus Bracing on Postural Stability of the Ankle

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THE EFFECTS OF TAPING VERSUS BRACING ON POSTURAL STABILITY OF THE ANKLE

by

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This Scholarly Project, submitted by Rachel Johnston, Lindsey Kramer, Leah Nikle and Heather Stecher in partial fulfillment of the requirements 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, Physical Therapy)

PERMISSION

Title	The Effects of Taping Versus Bracing on Postural Stability of the Ankle
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ABSTRACT

External ankle supports, such as athletic tape and braces, used prophylactically and postinjury, have enabled athletes to participate, when their absence would have either limited participation or possibly allowed an injury. These supports offer an extrinsic mechanical source of support for the ankle. The ankle, however, is also dependent on the proprioception system, including visual input, to maintain balance through motor involvement of regional ankle musculature. It would appear that the addition of external support would enhance the overall integrity of the ankle; however, does that support exert an influence, positive or negative, on the proprioception system at the joint? The purpose of this study was to determine the effect external support on the proprioception system via balance assessment and to determine if that effect is different when comparing athletic tape to an ankle brace.

Thirty-three healthy male and female subjects (mean age 24.3 years) participated. The Balance Master 8.2, a computerized balance assessment device, was used to test and compare the effects of bracing, taping, and control on the ankle while performing the Unilateral Stance test with eyes open and closed, and the Step/Quick Turn test. Each subject randomly selected a face-down card to determine which ankle would be tested, which test they would begin with, and the order of control, tape, and a brace.

There was a statistically significant difference in the Unilateral Stance with eyes closed test. There was no statistical difference between the supported conditions;

however, significance was demonstrated when unsupported and supported were compared, with increased postural sway exhibited in supported conditions. There were no other statistically significant differences among the other tests and conditions.

These results support previous findings in which external support coincided with increased postural sway. Our study also showed that no difference in postural sway occurred between different forms of support, whether they involved an extensive contact area such as athletic tape or reduced contact area such as a low profile brace. These findings suggest that the proprioceptive system is less involved in maintaining balance when an external ankle support is applied.

CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

Incidence of Ankle Sprains

Ankle injury prevalence has been well documented throughout the literature. As one of the most often injured anatomic sites in people involved with competitive or recreational athletics, approximately 85% of ankle injuries are acute ankle sprains,[1] nearly seven times more frequent than all other ankle injuries.[2] In the United States it is estimated that the daily tally for ankle sprains is more than 25 000, which amounts to roughly 9 million annually.[2-3]

Incidence by sport, gender, and occupation has been studied and documented in research to expand upon the characteristics of ankle injuries. Ankle sprain injury involves injury to the ligaments of the foot and ankle; in severe cases the tendons can be involved. In the classification of an ankle sprain, a fracture cannot be present.[4]

Comparing relative risks for ankle sprain injury across sports or vocation is difficult secondary to different methods of quantifying risk. Despite the difficulty in quantifying ankle sprain injury risks, there appear to be three important factors leading to a higher incidence; these include the sport or work requirements that place an individual at risk for ankle sprain injury, previous history of ankle sprain injury,[5] and dorsiflexion range of motion.[6]

Virtually no sport is left untouched by ankle injuries. However, higher incidences can be seen in soccer, basketball, football, and gymnastics.[1-2, 5,7] Surve et al[8] reported the rate of incidence at 0.86 sprains per 1 000 playing hours for male soccer players and 0.46 ankle sprains per 1 000 playing hours for previously uninjured players. McKay et al[9] observed 10 393 recreational basketball participations and documented 3.84 ankle sprains per 1 000 participations. Also increasing the incidence, players with a previous history of ankle sprains were 5 times more likely to sustain an injury.[9] Similar studies have shown comparable results.[10-11]

Sports are not the sole constituents responsible for higher incidences in lateral ankle sprains. Occupational components may have just as an accountable role. Careers involving sudden position changes, pivoting maneuvers, and uneven ground surfaces increase the probability of injury. Military personnel can be included in the description. Persons who parachute jump without braced ankles had an injury rate between 3.7 and 4.5 ankle injuries per 1 000 jumps,[12-13] and infantry recruits, reported by Milgrom et al,[14] had an ankle sprain incidence rate of 18% during the course of basic training.

Also addressed in the Milgrom et al[14] study were anthropometry and risk factors. Military personnel who were taller and heavier were at a significantly higher risk to incur a lateral ankle sprain injury. The authors contributed these anthropometric risks to an amplified momentum and mass moment of inertia about the ankle joint, necessitating more resistance to inversion moments caused by ground reaction force during traumatic ankle sprain incidents.[14]

Comparing ankle injury, one study found that female basketball players were 25% more likely to sustain a Grade I ankle sprain injury as compared to male basketball players.[10] Similar results were found by Beynnon et al[15] in a study comparing the effects of sex, level of competition, and sport on the incidence of injury. They concluded the risk for suffering an ankle sprain was higher for women versus men, but it was statistically insignificant. However, there was a significant difference showing female basketball players were at a higher risk when compared to male basketball players and female lacrosse athletes for ankle sprain.

There has been some evidence to support a difference between sex and risk factors, but the research is limited as to whether there is a noteworthy difference. When looking at ligamentous laxity, Wilkerson et al[16] found that when stressed to the same level on a Telos ligamentous stress device, there was a statistically significant difference in greater ligament laxity of the lateral ankle in women versus men.

Gender prevalence for ligament laxity may not be present just at the ankle joint. Other studies have shown instability may occur in the knees more frequently in women versus men. According to Gwinn et al,[17] female varsity athletes had a relative risk of greater than 9 in soccer for anterior cruciate ligament (ACL) injury, which was statistically significant. Other sports were not statistically significant, but did show a difference. Overall, there was a 4 times greater likelihood of ACL deficiency in women when compared to men, which was statistically significant. Similar results were found by other researchers, potentially guiding one to infer greater laxity of lower extremity joints in women, leading to a greater risk of injury.[18-20]

Anatomy of the Ankle Joint

The proximal and distal tibiofibular joints, talocrural joint, and subtalar joint combined create the osteokinematic and arthrokinematic ankle motions about the foot. A slightly convex tibial facet and slightly concave fibular facet form the proximal tibiofibular joint, which is encircled by a joint capsule and toughened by anterior and posterior ligaments, namely proximal tibiofibular and anterior and posterior ligaments of the fibular head. The distal tibiofibular joint is formed through the union of a concave facet on the lateral aspect of the distal tibia and a convex facet on the distal fibula. Ligaments also reinforce the stability of this joint, and include the anterior and posterior tibiofibular ligaments and the crural interosseous tibiofibular ligament. An interosseous membrane between the tibia and fibula also helps support both joints. The characteristics of the tibiofibular joints allow small amounts of movement, as the proximal joint is synovial, permitting superior and inferior sliding of the fibula on the tibia and slight rotation. The distal joint is a syndesmosis joint but does allow a small amount of motion.[21]

The talocrural joint includes articulations between the distal tibia and fibula and the talus. The proximal portion of the joint is comprised of the concave surfaces of the distal tibia and the tibial and fibular malleoli. The convexity of the dome of the talus forms the distal portion of the joint. This joint is surrounded by a joint capsule, although weak anteriorly and posteriorly. To compensate, the anterior and posterior talofibular ligaments and the calcaneofibular ligament provide lateral support. For reinforcement of the medial side, the deltoid ligament is the stabilizing structure.[21]

Dorsiflexion and plantarflexion are the motions demonstrated at this joint. Due to the oblique axis, the motions do not occur in a purely sagittal plane. Consequently, the motions happen in three planes, and thus are considered to be triplanar. Weightbearing versus non-weightbearing positions alter the movement of the osseous anatomy. In weightbearing, the tibia moves anteriorly in dorsiflexion, and posteriorly in plantarflexion. While in non-weightbearing positions, dorsiflexion of the ankle will move the talus posteriorly, while plantarflexion will cause an anterior movement. Because the talocrural joint is designed for stability, especially during dorsiflexion, the talus is shaped to prevent or limit inversion and eversion while it is wedged between the medial and lateral malleoli.[21-22]

The last joint to also contribute to ankle activity is the subtalar joint, comprised of three single plane articulations between the talus and calcaneus. The anterior and middle articulations are made up of two convex facets on the talus and two concave facets on the calcaneus and share a joint capsule with the talonavicular joint. The largest articulation, the posterior, has its own joint capsule and consists of a concave facet on the inferior surface of the talus and a convex facet on the body of the calcaneus and has its own joint capsule. The ligaments, including the anterior, posterior, lateral and medial talocalcaneal, and the interosseous talocalcaneal strengthen the subtalar joint.[21]

Around another oblique axis, the motions of inversion and eversion are permitted at this joint. A combination of abduction-adduction, flexion-extension, and supination-pronation comprise these motions. At the subtalar joint, secondary to the convexity and concavity of the facets, a twisting motion of the calcaneus on the talus is created. While in eversion the calcaneus slides medially, and during inversion it glides laterally.[21]

Muscles which function to provide additional stability and postural control include the fibularis longus and fibularis brevis for the action of eversion. Plantarflexion of the ankle is controlled by the primary muscles, gastrocnemius and soleus. Tibialis anterior, extensor digitorum longus, and extensor hallicus longus perform the action of dorsiflexion. Inversion movements of the ankle consist of: tibialis anterior, flexor digitorum longus, flexor hallucis longus, and tibialis posterior. The ankle is a very involved joint, with different muscular functions to help complete activities.[4]

Ankle Sprain Prophylaxis

The prevention of lateral ankle sprains has been widely researched and studied. As a result, some evidence has been promoted to prove the effectiveness of some types of external support. This, however, remains controversial as to whether or not the external support added to the ankle actually reduces the number of ankle sprains and/or the severity of the sprain.[23]

The practice of taping has been dated back over 100 years to an article published in 1895 in the *New York Medical Journal*.[24] The technique used by Gibney[24] at that time was for the treatment of ankle sprains; however, the technique now has more extensive use as a preventative measure. Even though the materials used over a century ago have changed, the technique still has three main components used today, including "stirrup strips," "horseshoe strips," and a "heel lock."[24]

Garrick and Requa[25] were one of the first researchers to establish a positive relationship between prophylactic taping and its efficacy. More than 2 500 intramural college basketball players participated in a 2-year study of taping paralleled with no taping. The study cited a more than 50% reduction in sprains for those athletes with prophylactic taping.[25] This study, however, has yet to be reproduced to the magnitude of its original statistics.

Even though the reductions to the extent of that study have not been replicated, other studies have shown benefits from ankle taping. A study done by Shapiro et al[26] tested 5 cadaveric ankles and the effects of taping as well as other prophylactic measures. Tape was effective in increasing the resistance of the ankles to an inversion moment applied to the ankle in a neutral position as well as the ankle in 30° of plantarflexion.[26]

With persons who have a history of previous ankle sprains, prophylactic taping has again shown to be beneficial, according to a meta-analysis done by Olmsted et al.[2] The search closely examined 8 articles which met the inclusion criteria, and an analysis was performed on the numbers needed to treat and cost-benefit of taping along with other prophylactic forms. They concluded taping does appear to be more effective in preventing ankle sprains with those subjects who sustained at least one prior ankle sprain.

Another thoroughly studied type of prophylaxis is bracing. To decrease the repercussions of taping, including efficacy, cost, time, etc, bracing studies have been researched and compared to the effects of taping. As a result, literature is continually expanding upon the potential advantages of bracing as a prophylactic method in the prevention of ankle sprains.

The meta-analysis done by Olmsted et al[2] also studied the effects of bracing. Similar results were obtained in regards to increased effectiveness in preventing ankle sprains in persons with a previous ankle sprain.[2] A study done by Ubell et al[27] also concluded brace efficacy when landing with 1 foot unexpectedly forced into an inversion moment. Nishikawa et al[28] and Tropp et al[29] furthermore concluded positive protection against ligamentous inversion sprains with ankle bracing.

Taping versus Bracing

A debate, which has lasted for many decades, is still ongoing in deciphering the best preventative measure in regards to ankle stability and control, while still allowing adequate proprioception and functional mobility. A multitude of factors must be considered when choosing an appropriate method for prevention of lateral ankle sprains, including time, cost, efficiency, physical activity performed by the individual, and personnel to apply the support. Advantages have been evidenced for both taping and bracing, as well as disadvantages. As of now, no decisive conclusion has been established.

In considering which prophylactic method to choose, time is clearly a component to take into account. Berkowitz and Bottoni[30] currently carried out a prospective randomized study comparing a semirigid brace and conventional taping on high school football players. For one season, 97 minutes was estimated to be the amount of time needed to tape one ankle.[30] Bracing, conversely, can be instructed once and if properly learned, no more time is needed.

Another significantly important factor to contemplate is cost. The individual and/or coaching personnel must first decide whether the support method is worth the monetary issues in comparison to the likelihood of someone sustaining a lateral ankle sprain injury. After the decision has been made, one then will have to evaluate the differences between prophylactic methods. When looking at the taping process, prewrap, tape adherent, heel and lace pads, rolls of tape, and the salary of an athletic trainer or other qualified personnel must be examined. Bracing, however, requires usually only a one-time cost for the purchase of a brace. Olmsted et al[2] reported that taping would be 3.05 times as expensive as ankle bracing over the course of a competitive season. Similarly, Comeau[31] found that to tape both ankles of one person, the cost of purely the roles of tape would be $192 per person for sixteen weeks compared to the cost of a brace ranging from $20 to $60. The cost of tape did not include prewrap, adhesive spray, personnel to apply the tape, or heel and lace pads, whereas the cost of the brace is one time and no additional costs usually are added.

Efficacy of ankle sprain support is also widely questioned. Does the method have the quality effects necessary to last the entirety of the athletic event or length of time which is needed? Again, much controversy has been established for taping, and similarly, for bracing.

Rarick et al[32] were among the first to report that within the first 10 minutes of exercise, athletic tape lost approximately 40% of its initial support. The effectiveness of taping was also shown to be diminished with the movable nature of the skin and perspiration, as shown in the study done by Ferguson.[33] Another study done by Greene and Hillman[34] noted that athletic tape once again was unsuccessful in maintaining a consistent amount of support for extended periods of time.

Even though prophylactic bracing may have advantages over taping, there exist limitations with bracing. Gross et al[8] and Greene and Wight[35] both reported similar results of a decline in effectiveness of support of braces after exercise. Another study showed that braces were not as efficient as freshly applied athletic tape in reducing the inversion moment at the ankle.[36]

To combat some of the ineffectiveness, proposals have been given. For proper use of bracing, a relatively vigorous activity period during the break-in time and periodic adjustment of the lacing system have been recommended.[8] Athletic tape, however, cannot realistically endure the same recommendations, short of additional tape applications over time.

Effects of Prophylaxis on Performance

Of main concern to most athletes is the effect the prophylactic method will have on their performance. A plethora of studies have evaluated the effects of ankle taping and bracing in regards to athletic abilities of running, jumping, cutting, etc. Main concerns to those responsible for the care of the athletes are the biomechanical and neuromuscular effects, which have also been studied, in the presence of prophylactic methods.

When examining agility, Beriau et al[37] indicated a significant difference between two different types of ankle braces, yet contributing factors of perceived comfort, support, and performance restriction may directly influence the effectiveness of bracing. Taping effects on agility have also been studied and been shown to have restrictions in running and jumping activities.[38-39]

Reiemann et al[40] studied the time to reach peak forces on vertical ground reaction forces and concluded the time to reach peak forces was significantly less under the ankle tape and brace conditions when compared to no stabilizer. This indicates that during dynamic activity the musculoskeletal structures of the body may be subjected to loads within shorter periods of time, imposing higher stresses on muscles and ligaments and decreasing energy absorption.[40] However, Wikstrom et al[41] measured dynamic postural stability in subjects who had previous ankle injuries with prophylactic ankle stabilizers (PASs) and concluded no significant difference in vertical ground reaction forces but an improvement in the vertical component score of the Dynamic Postural Stability Index with a soft or semirigid PAS.

Verbrugge[42] reported that neither taping nor bracing had any substantial effect on agility, sprinting speed, or vertical jumping ability. Similar studies and reviews concluded likewise.[7, 43-44] A meta-analysis done by Cordova et al[45] concluded that any adverse effect on athletic performance was much outweighed by the positive benefits of prevention.

Some researchers have studied the effects of prophylactic methods on motion at the knee and hip joints. Santos et al[46] found that the use of an ankle brace resulted in reduced trunk axial rotation during ball catching tasks, and increased knee axial rotation during target touching tasks. If an athlete were required to rotate the trunk forcefully while standing on one leg, an ankle brace may cause an increase in knee axial rotation and higher risk of knee injury.[46]

In reference to postural control, effects of ankle taping and bracing have been measured. Even though it may seem like prophylactic applications provide mechanical support and enhance proprioceptive input, the effects are unclear. A study measuring the effects of tasks in the frontal plane (balance tasks requiring estimation of balance and both right and left deviations) concluded there was no significant difference among the conditions of brace, tape, or no support.[47] The study concluded the effects of the stabilizers were undecided.

A study done by Kinzey et al[29] researched the proprioceptive input at the ankle with measuring the center of pressure during posture with braces and no brace. The study concluded that their results neither supported nor refuted the concept that bracing enhances proprioception.[1]

CHAPTER II

METHODOLOGY

Setting

All participants were required to be present in research room 2541 in the Physical Therapy Department at the University of North Dakota. The research room held only the subjects individually and the researchers. In the room, distractions and excess noise were diminished to the lowest level possible.

Participants

Thirty-three individuals (16 males and 17 females) willingly participated in this study. The mean age was 24.3 (20-38) years. For participation each subject had to be a healthy adult with no previous acute or chronic ankle injuries, balance or vestibular problems, or current pregnancy. Other factors influencing their participation included no allergies to athletic tape, prewrap or cotton, and each subject was required to have a pair of athletic shoes in good condition to be worn throughout all of the testing.

Each subject randomly selected a face-down card to determine which ankle would be tested, which test he/she would begin with, and the order of condition. Before the study, each participant was asked to sign a validated consent form, reviewed and approved by the Institutional Review Board, in accordance with the University of North Dakota's policy governing the testing of human subjects (Appendix A). To ensure that all research involving human subjects met regulations established by the United

States Code of Federal Regulations, the University of North Dakota's Office of Research and Program Development reviewed and approved this study.

To maintain confidentiality among subjects, each person signed a consent form which was numerically marked, and then that number was assigned to him/her throughout the remainder of the study. The number was typed into the computer system when testing began. The consent forms and the data associated with them were stored in separate locked cabinets within the Physical Therapy Department. The only persons with access to this information are the researchers, and after 3 years have passed, it will be destroyed.

NeuroCom® Balance Master

To effectively address the effects of ankle taping versus bracing on ankle postural control, each subject was tested using the NeuroCom® Balance Master 8.2 (NeuroCom International, Inc; Clackamas, OR). The Balance Master is often used by physical therapists for the assessment of balance, postural sway, and functional skills. It uses a computerized software program which receives input from 2 forceplates. The 2 moveable plates measure the vertical forces exerted by the individual's feet. Once the data is transferred into the computer, it can then be analyzed using the screen's display or a print-out of the individual's results. The Balance Master has the computer screen facing towards the person performing the assessments to assist in the instruction of each test. Each test offers a prompt for the individual to begin the test by both a visual and auditory cue.[48]

Procedure

Each participant will be tested using 1 leg and 2 Balance Master tests. The tests will be performed using 3 different ankle strategies: control (no external support), a minimal contact brace, and tape. To begin the testing process, each person was asked to report to the Physical Therapy Department. After reading the consent form, each participant signed it and received their own copy, if they desired. Upon completion, they were individually screened. The screening process consisted of completing a short questionnaire to assure the participants had met the inclusion/exclusion criteria and passing the sharpened Romberg test to screen for balance disturbances (Appendix B). This was done in a secluded room in order to maintain confidentiality and minimize distractions.

When in the research room, participants randomly selected, from face-down cards, which ankle would be tested. After this, they randomly selected, as in the previous procedure, the support structure of which the ankle would be tested (control, brace, or tape). The last selection of cards determined which test they would perform first. After they completed the 2 tests, they again randomly selected between the last 2 cards whether to be taped, braced, or neither, depending on the elimination of the first round. Again, they randomly selected which test they would perform first with the different support structure. The last support structure was then tested, once more with the participants randomly selecting which test would be done first.

The Balance Master tests we chose for our study included the Unilateral Stance (US) and the Step/Quick Turn (SQT). Both of these tests are functional ability assessments, which is of value when analyzing postural sway in the ankle. According to the Balance Master 8.2 manual, the US measures the amount of postural sway velocity in degrees per second (deg/sec) while maintaining balance on 1 leg. This test was completed on the selected ankle with eyes open as well as eyes closed. Prior to the start of each test, each subject completed a practice run to eliminate the learning curve effect. Each test trial consisted of a 10-second testing period, which was completed 3 times to cumulate an average mean sway velocity for each subject. A 10-second rest period was given between trials to eliminate muscle fatigue.

Each subject was assisted in the proper foot placement on the forceplates according to the Balance Master Version 8.2 Operator's Manual.[48] To ensure accuracy, the same researcher aligned the subject's medial malleoli of the testing ankle on the appropriate line. The subject was then given instructions on how to correctly perform the US. Subjects were asked to keep their hands placed on their hips throughout the entire test, while remaining as steady as possible. Subjects were then asked to lift their nontest foot off the forceplate into the position shown in Figure 1, while maintaining their balance for the 10-second trial period.

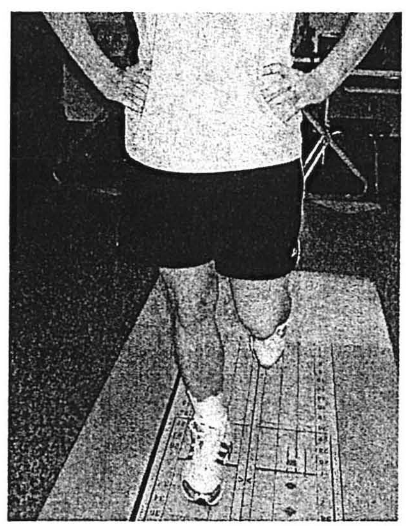


Figure 1. Unilateral Stance position with taped ankle

When testing with their eyes closed, subjects were asked to first lift their foot and then close their eyes. The trial began when the researchers saw the subject had completed these steps. A trial was allowed to run the full 10 seconds unless the subject's non-weightbearing foot touched the forceplate for greater than 1 second, the spotter came in contact with the subject due to loss of balance, if he/she were unable to maintain the proper foot alignment, or if the subject's eyes opened during the eyes closed test trials. Each subject was allowed 1 trial to be marked as a fall, which was not recorded in the data. If a fall were to be recorded, it was then given the maximum value of "12", indicating a sway velocity well beyond the range of normal. The US was performed in this same manner for all 3 ankle conditions.[48]

The SQT assessment requires the subject to take 2 forward steps, followed by a quick 180° pivot turn and 2 steps to return to the starting position facing away from the computer screen until the trial was recorded. This test measures both turn time (seconds) and turn-sway velocity (degrees). For our study, we chose to only analyze the turn-sway velocity since we were looking at the effects of the 3 ankle conditions and how they affect postural stability. Each subject watched a Balance Master video instruction on how to perform the STQ, with the opportunity to practice until he/she felt comfortable with the testing procedures. The test was then performed for a series of 3 trials, including a 5-second resting period between trials. Each trial was begun with the subject standing on the end of the forceplates. Upon computer signal, the subject began the 2 steps starting with the test foot, completed a pivot turn towards the test side, and finished by taking 2 returning steps. The STQ was also completed under each of the three testing conditions for each subject.[48]

Ankle Brace

When deciding on what kind of brace to use on the subjects' ankles, a couple of factors were considered. The features desired were less contact around the ankle and foot (unlike taping which has full contact), a brace that allowed movement in the sagittal plane, and one that could be used on the right or left ankle.

The brace chosen was the T2 Active Ankle® (Active Ankle Systems, Inc., Jeffersonville, IN), which "features a durable, quick-fitting single strap system that is adjustable for both high- and low-top shoes."[49] Sizes of small, medium, and large were purchased to adequately fit a broad range of ankles in this study. The same researcher assisted in the brace application according to the Active Ankle fitting instructions.

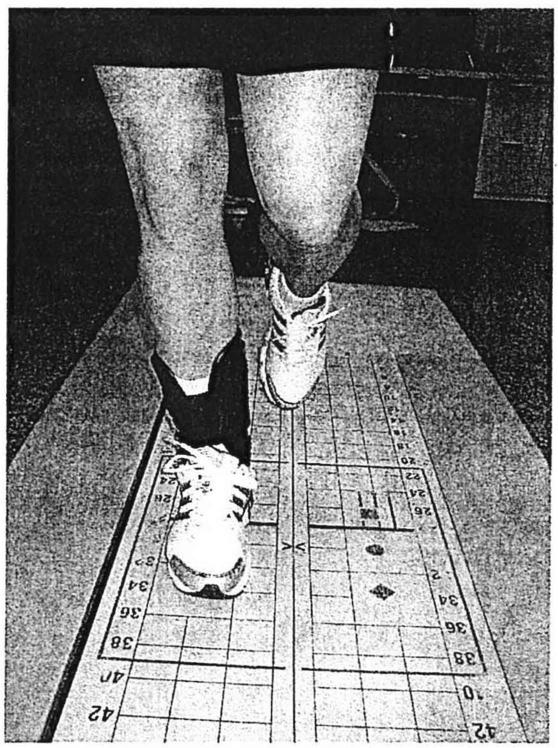


Figure 2. Unilateral Stance with ankle brace

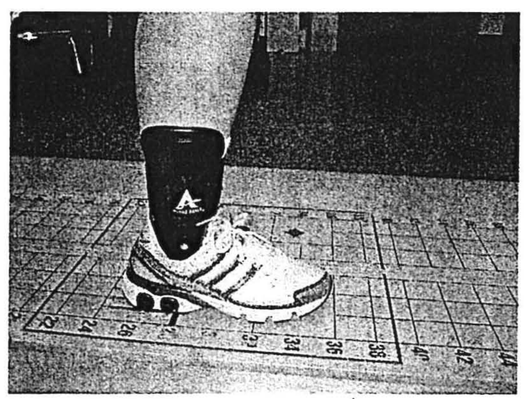


Figure 3. Lateral view of ankle brace

Taping Technique

This study is a continuation of a previous study done by Brown et al.[50] In order to help assure consistency of procedure, the taping technique, the closed Gibney method, for this study was identical to their procedure.

Each participant sat in the longsitting position with the ankle to be tested positioned slightly off the edge of a plinth to have the taping technique completed. The participant's ankle was held in 90° of dorsiflexion throughout the entire taping procedure. To protect the skin from athletic tape, prewrap was applied prior to taping the lower leg and ankle. One half-inch Mueller Tape® (Mueller Sports Medicine Inc., Prairie du Sac, WI) was used in this study. Two anchor strips were applied circumferentially around the base of the gastrocnemius muscle belly. Distal to the base of the fifth metatarsal, a single anchor was placed around the foot. Next, in the direction from medial to lateral, 3 stirrups were placed. 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.[50]

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 in front of the ankle joint and 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 began 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 heel locks. This taping method uses a total of 11 strips of athletic tape.[50]

Following the taping procedure, prior to any testing on the Balance Master, each subject was instructed to walk up and down 2 flights of stairs and perform simulated athletic activities for 10 minutes to replicate the loosening that occurs shortly following application and to simulate the state of rigidity the tape would have during competitive athletic performance.[32,34]

Main Outcome Measure

Data collection was performed through the use of the Balance Master. The US, with eyes opened and closed in all 3 testing conditions, was measured in velocity of degrees per second to calculate the amount of postural sway occurring. All 3 testing conditions of the STQ were measured in degrees to analyze the amount of sway while performing the pivot turn. Postural sway is a key indicator of the amount of movement occurring in the challenged ankle. An increase in postural sway at the ankle is indicative of less postural control in that joint.

Statistics

A single factor repeated measures analysis of variance (RM ANOVA) was used to analyze the differences among the 3 ankle conditions of control, brace, and tape trials for each test (US & SQT). Results of this analysis were reported as means $\pm$ standard deviation, F value, and significance levels. An alpha level of $p<0.05$ was set for statistical significance. Statistical analysis was performed using SPSS-11.0.1 software (Lead Technologies Inc, Chicago, IL).

CHAPTER III

RESULTS

A total of 33 subjects were involved in this study. A summation of all test means and standard deviations are provided in Table 1. All participants were included in the data analysis with the exception of 2 participants in the US with eyes closed. Both participants were removed due to inability to maintain full concentration.

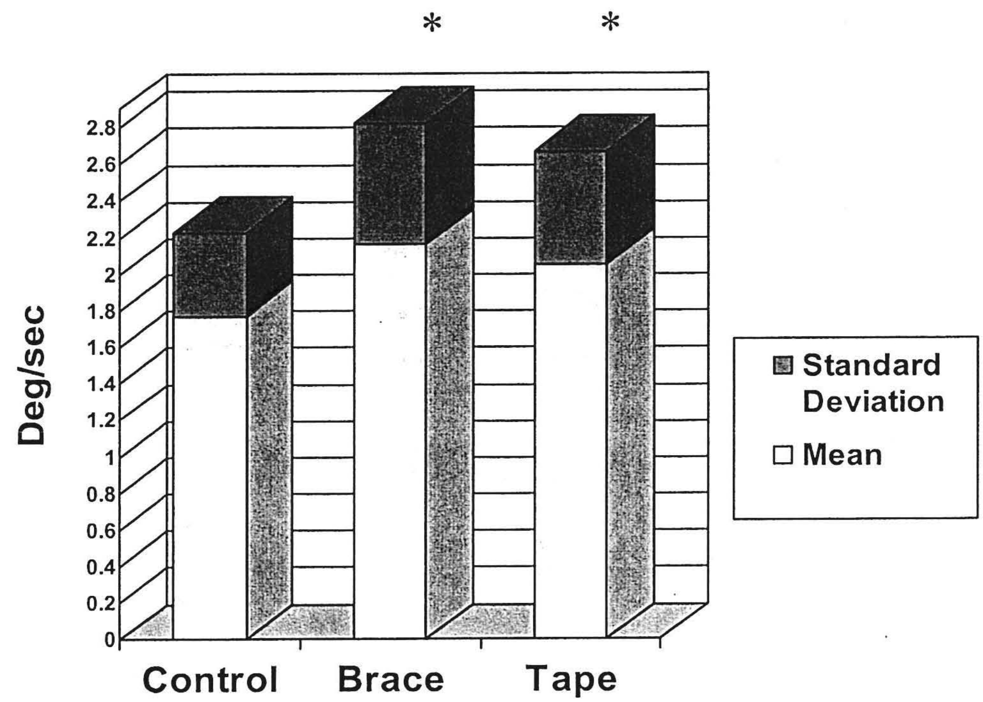
Significant difference was noted in the US with eyes closed (Table 2 and Figure 4). Under post hoc analysis, the control group mean (1.78 deg/sec) was significantly lower than either the brace group mean (2.16 deg/sec) or the tape group mean (2.05 deg/sec), with $p \leq 0.001$ in both comparisons. However, there was no significant difference between the brace and the taping groups in this test. No other significant differences were noted in any of the other tests performed.

Table 1. Sway Velocity and Turn Sway Descriptive Statistics			
	Mean	**N**	**Std. Deviation**
US Eyes Open (deg/sec)-Control	0.59	33	0.15
US Eyes Open (deg/sec)-Brace	0.61	33	0.14
US Eyes Open (deg/sec)-Tape	0.61	33	0.17
US Eyes Closed (deg/sec)-Control	1.77	31	0.46
US Eyes Closed (deg/sec)-Brace	2.16	31	0.66
US Eyes Closed (deg/sec)-Tape	2.05	31	0.62
SQT (deg)-Control	18.83	33	5.17
SQT (deg)-Brace	17.90	33	4.07
SQT (deg)-Tape	18.36	33	5.75

* Unilateral Stance (US), degrees/sec (deg/sec), Step/Quick Turn (SQT), degree (deg)

Table 2. Sway Velocity and Turn Sway Statistical Analysis				
	F	**P**	**Eta^2**	**Power**
US (deg/sec) Eyes Open Control vs. Brace vs. Tape	0.28 (2, 64)	0.60	0.01	0.08
US (deg/sec) Eyes Closed Control vs. Brace vs. Tape	15.59 (2, 60)	0.00	0.34	1.00
SQT (deg) Control vs. Brace vs. Tape	0.77 (2, 64)	0.47	0.02	0.18

* Unilateral Stance (US), degrees/second (deg/sec), Step/Quick Turn (SQT)



* Significance denotes difference between supported (brace and tape) and control groups at p<0.05

Figure 4. Sway velocity comparison for Unilateral Stance with eyes closed

CHAPTER IV

DISCUSSION AND CONCLUSION

Discussion

This study examined the use of external ankle support and the effect of postural stability. There was a statistically significance difference found in the US with eyes closed when either tape or brace was applied in comparison to no ankle support. An increase in postural sway was observed with both of the prophylactic methods. However, there was no statistical difference between the two preventative measures. Similarly, Brown et al[43] also found a statistically significant increase in postural sway with the ankle taped as compared to no support.

An increase in postural sway during the eyes closed US could be a reflection of the visual system and its influence on balance. When the vision system was disturbed, the postural sway was increased. The effects on postural sway were only affected during an interruption of vision. Even though no significant difference was seen in sway velocity with eyes open among the treatment conditions, it should be noted that the mean sway velocity was 30% that of sway velocity among the groups with eyes closed. This difference in sway velocity between visual conditions further demonstrates the substantial influence this system has in postural control. The suggestion that greater contribution to postural control comes from the visual system rather than ankle proprioceptors has been documented in the literature. According to Riemann et al[51] when the lateral ankle ligaments were isolated and anesthetized, postural stability was not significantly affected. It would appear that the ankle mechanoreceptors, therefore, have a lesser role on single leg stance stability.

Despite the addition of increased support while wearing an ankle prophylaxis, it appeared that the area it assisted more was the structural component, rather than giving increased proprioceptive input. Due to the finite movements at the ankle when it is unsupported, adding a prophylactic method to further limit ankle movement may influence hip and knee strategies. When a brace or tape was applied, increased postural sway could be due to the decreased allowance of the finite movements at the ankle, which are then taken over by the hip or knee, therefore increasing the degree of postural instability.

This study showed an impairment in proprioception with both brace and tape. A negative implication with wearing ankle prophylaxis could potentially be the complications in long term effects. A continual cycle of impairing the proprioceptive system may lead to even more markedly weakened proprioception and consequences later in life. With a decrease in the vision system as one ages, coupled with decreased proprioception at the ankles, it leaves an increased risk for falls and balance disturbances.

To defer the probable complications of decreased proprioception with long term wearing of ankle prophylaxis, issues of when and how to transition the individuals from support to no support should be speculated. Currently, the literature is not abundant with time frames or prognostic indicators for these issues. More research should be done to examine the possibility of residual proprioceptive deficit with extended use of external ankle support.

Limitations

Even though the use of standardized methods was followed, some limitations are unavoidable. For this study, environmental distractions, personal internal and external preferences, equipment confinements, and testing procedural variations could have been more defined. Hopefully they could be decreased or eliminated if further research follows this study and modifies according to the that listed below.

Environmental distractions include a wide variety of characteristics. These can include the temperature in the room, noise distractions of people conversing outside of the testing room, and possible visual distractions from the researchers moving about inside the testing room. Although the researchers tried to keep distractions at a minimum, some subjects' concentration could have been altered by any environmental distraction.

Personal preference of individual subjects will vary between people. The preconceived preference of either tape or brace may affect the willingness of participation depending on the type of prophylactic previously worn. Earlier use of either brace or tape could also affect the subject's comfort level and confidence of wearing the same type or a different type of taping method.

Individuals tested most likely had different motivational levels, as well as differed in activities done prior to testing. There were no regulations on amount of physical activity performed prior to testing, a condition which could have affected the fatigue level experienced during testing. Boredom during testing could have had a possible effect on performance, as well as external factors, such as the type of shoe worn. This study allowed subjects to wear their own athletic shoes. Aspects of how long they had their shoes, what activities they used their shoes for, and the make and model of their shoes were not standardized to beyond less than 2 years' wear and less than or equal to a 2-in heel height.

Equipment limitations, whether from the Balance Master, taping technique, or the brace, were experienced. Reliability of the Balance Master is not at 1.0; rather, it is at 0.6, decreasing the power of reliability. The US, according to the Balance Master manual,[44] has poor to moderate reliability, and the SQT has moderate to high reliability. The taping procedure was standardized; however the exact amount of pressure and pull applied to each individual could have been variable. There were three different sizes of the brace used to accommodate for subject variability; however, the brace fit may still not have been ideal for the subject.

With the standardization procedures that were used, some variations were allowed. The standing position during US had certain positions of hands on hips, ankle placement on the Balance Master, and the non-weightbearing foot could not touch the forceplate for greater than one second or touch the other leg. Even though this was followed, the degree of hip and knee flexion and the position of the non-weightbearing foot were not specified. During the entire testing procedure, a script was read to the subjects; however, the exact same emphasis on words and phrasing may have been altered.

Recommendations

After completing this research study, we became aware of issues that can be addressed for further studies. To increase the value of future research, the following recommendations should be considered.

Ways to help increase the significance of the findings include having a larger sample size which will help raise the power of the study. Greater variability in subjects' age, body type, and activity level would be a better representation of the general population. The subjects included in this study had a mean age of 24.3 years, high daily activity levels, and healthy body types.

Our study only included one specific type of brace; further studies should look at different types of ankle braces. There are a variety of ankle braces that may be a better fit for each individual participating in the study. By testing a wider variety of ankle braces, the best fit and subject's comfort level could increase accurate performance; although, this would create increased variability.

Future studies should include activities that are representative to athletic populations. Sport specific movements include, but are not limited to, the following: running, jumping, cutting, planting, and changing of directions. By analyzing how the ankle performs during these sporting activities, researchers could assess which external ankle support was more beneficial to the athlete's postural stability during more functional activities.

A study to be completed with subjects that have sustained ankle sprains or have ankle pathologies should be done in order to assess the effects tape or brace have on an unstable ankle joint. This study was completed on individuals that had no chronic or acute ankle sprains. By using subjects that currently have an ankle sprain, a better understanding of the contribution of the external support to proprioception and mechanical support might be evident. Another component to consider is grouping the study according to the degree of ankle sprains. By separating the degrees of ankle sprains in the study, researchers could further analyze if brace or tape would be a more effective method for support at the ankle.

Conclusion

This study found an increase in postural sway during US with eyes closed, when either brace or tape was applied to the ankle. However, there was no difference between external ankle supports. The SQT and US with eyes open showed no statistical differences in amount of sway.

The application of either bracing or taping had a negatively significant effect on instances with eyes closed while standing on one leg. The loss of the visual system could be inferred to help manifest the decrease in proprioceptive capability while an ankle support is in use. The external ankle support may relax the ankle proprioception system as the support itself offers a degree of mechanical support to the joint. Since neither brace nor tape demonstrated an advantage over the other in regards to postural control, other factors such as time, cost, comfort, mechanical support, and available personnel for its application will be those that help determine which is preferred for mechanical support for the ankle joint.

APPENDICES

Appendix A

INFORMATION AND CONSENT FORM

The Effects of Ankle Taping versus Bracing on Postural Control:
A Balance Master 8.2 Assessment

Principal Investigators: Lindsey Kramer, Leah Nikle, Rachel Olson, Heather Stecher, and Mark Romanick from the Department of Physical Therapy at the University of North Dakota

You are being asked to participate in this study of postural control of the ankle during functional activities, with taping, without taping, and with an ankle brace of less contact than athletic tape. The purpose of this study is to determine the effects of ankle taping versus bracing on postural control. We hope this study will aid not only physical therapists, but other health care providers, in justification that ankle bracing is more cost effective and more beneficial to the individual.

You were chosen because: 1) you are a healthy young adult between the ages of 18 and 39 years old, 2) you have no current ankle injury, 3) no chronic ankle injuries, 4) you are not currently pregnant, 5) you have no allergies to athletic tape, pre-wrap or cotton socks, and 5) you have no history of balance disorders, such as vestibular problems or inner ear trauma.

As a subject in this study, you will be invited to the Physical Therapy Department at the University of North Dakota, located in the Medical Science North Building. Your age, height and weight will be recorded by one of the researchers. After this, you will be asked to remove your shoes and socks for tape and brace applications. Each test will be performed wearing clean cotton socks, which will be provided, and your athletic shoes. You will be randomly assigned to the following: right or left ankle, the order of brace, tape, or neither, and the order of the Balance Master 8.2 Tests (single leg stance and step quick turn). You will complete a practice run for each of the tests prior to performing the recorded test on the Balance Master 8.2. The single leg stance will be performed with eyes opened first, and then eyes closed. The step quick turn involves taking two steps, making a 180 degree turn, and then taking two more steps. When the practice set is over, you will then perform each test three times for each condition, one without taping or a brace, one with tape, and one with a brace for a total of twenty-seven recorded trials. The Balance Masterv8.2 monitors your postural control during each test. The length of the complete process should take no longer than one hour with breaks between trials as needed.

The risk of injury to you as a subject is relatively minimal. With any physical performance test, there is a risk. However, with this study there is a low level of intensity required with the activities of balance testing. You will have one spotter within close proximity of you in the event you should lose your balance. There is also a chance of unknown allergies and/or skin conditions related to tape, pre-wrap or cotton. UND, UND Physical Therapy Department, and the researchers of this study will not be held liable for any injuries sustained during this study.

In any reports of this study, your name will not be used. Information that is obtained by the researchers in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. A number known only to the investigators will be identified with the data. The only persons with access to this data are the researchers, advisor, and individuals who audit IRB procedures. For a length of three years, this consent form and the data associated with it will be kept in different locked cabinets. After three years have past, they will be destroyed.

You or the researchers may stop the experiment at any time if you are experiencing any type of pain, discomfort, fatigue, or other symptoms that may be harmful to your health. You have the right to participate, as it is voluntary and your decision will not discriminate your future relationship with the Physical Therapy Department at the University of North Dakota. If you do participate, you have the right to discontinue at any time without prejudice.

The researchers involved in this study are here to answer any questions you have in regards to this study. You are also encouraged to ask any questions concerning this study that you may have in the future. In the event you do have questions, you may call Heather Stecher at (701) 866-3851 or Mark Romanick at (701) 777-2831. Any further questions or concerns can be directed towards the Office of Research and Program Development at (701) 777-4279. In addition, you will be given a copy of this form for future reference at your request.

In the event that this research activity results in a physical injury, medical treatment will be as available as it is to a member of the general public in similar circumstances. You and your third party payer must provide payment for any such treatment. The researchers and the University of North Dakota will not be held liable for any injuries.

All of my questions have been answered and I am encouraged to ask any questions that I may have concerning this study in the future. I have read all of the above and willingly agree to participate in this study as it is explained to me by Lindsey Kramer, Leah Nikle, Rachel Olson, and/or Heather Stecher.

____

Subject's Signature   Date

Appendix B

Screening Sheet

1. _____ What is the date of birth for the participant ______________________________

2. _____ The participant is between the ages of 18-39 years old.

3. _____ What is the participant's height with proper testing shoes on _______________

4. _____ The participant is wearing tennis shoes that are in good condition and the heel is not greater than 2 inches.

5. _____ The participant does not have vestibular or balance problems, acute or chronic ankle injuries, pregnancy, knee problems, or allergies to athletic tape, pre-wrap, or cotton.

6. _____ The participant passed the Romberg Test

* By checking all of the above requirements the participant may continue to participate in the research study.

Appendix C

CONSENT FOR USE OF PICTURE

I, Jill Gibbon, do hereby give permission for the use of my photograph in this Scholarly Project, IRB # 200606-404.

Jill Gibbon
(Signature)

12/14/06
(Date)

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