THE EFFECTS OF PROPHALACTIC ANKLE BRACING ON COLLEGIATE WOMEN'S BASKETBALL ANKLE RANGE OF MOTION, STATIC BALANCE AND DYNAMIC BALANCE

By

Damian Ignacio Aguilar, ATC

A Thesis Presented to

The Faculty of Humboldt State University

In Partial Fulfillment of the Requirements for the Degree

Master of Science in Kinesiology

Committee Membership

Dr. Justus Ortega, Committee Chair

Dr. Whitney Ogle, DPT, Committee Member

Shannon Childs, MS, ATC, Committee Member

Dr. Sheila Alicea, Program Graduate Coordinator

May 2018

ABSTRACT

THE EFFECTS OF PROPHALACTIC ANKLE BRACING ON COLLEGIATE WOMEN'S BASKETBALL ANKLE RANGE OF MOTION, STATIC BALANCE AND DYNAMIC BALANCE

Damian Ignacio Aguilar, ATC

Ankle braces are often used by athletic trainers across the nation in hopes of preventing ankle related injuries. Since prophylactic ankle braces are widely used and accepted, it is critical to understand the effects prophylactic ankle braces are having on ankle functionality and postural control both in a braced and non-braced state. However, the effects of prophylactic ankle braces over the period of a season has limited research. Thirteen collegiate women's basketball players, who are required to wear prophylactic ankle braces through a 20-week season, participated in this study. The purpose of this study was to determine the effect of prophylactic ankle bracing on passive range of motion, static balance (COG displacement, COG pattern tracking over a period of time), and dynamic balance (COG displacement in a dynamic setting, COG pattern tracking over a period, reach measures through SEBT) in collegiate women's basketball players across a 20-week season span. We rejected the null hypothesis and found differences in ROM, increases in Postural Stability scores, and improvements with Limits of Stability (LOS) scores. We also found a significant decrease in the anterior/lateral quadrant of the ASL test which suggests a change in COG placement over the 20-week span of the season. Although wearing prophylactic ankle bracing over the period of season showed

shifts in ROM, improvements in COG location and postural stability scores, further research is needed on wearing ankle braces over a long period of time to determine when these changes are happening.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1: LITERATURE REVIEW

Individuals who have experienced ankle sprains account for a high percentage of clinician referrals and emergency room visits annually. Specifically, lateral ankle sprains, are one of the most common injuries athletes and individuals who are recreationally active sustain (Lin et al., 2010). According to Hale, S.A., Fergus, A., Axmacher, R., & Kiser K., (2014), “researchers have estimated that approximately 25,000 ankle sprains occur each day in the United States, equating to 1 sprain per 10,000 people.” Ankle sprains are one of the most common injuries in sports and occur nearly seven times more frequently than all other ankle pathology (Olmsted et al., 2004). In a closer look at ankle sprain incidence, research has also been done within individually categorized sports. According to a meta-analysis by Olmstead et al., (2004) based on numbers needed-to-treat and cost benefit analysis, sprains to the lateral complex account for 85% of all ankle sprains in soccer. It also stated ankle sprains comprise 10% to 15% of all injuries in American football. Smith and Reischl (1986), took a survey of 84 male varsity basketball players and reported on the incidence of fibulocollateral ligament ankle sprains in the young male athletes. The surveys showed 70% of players had a history of an ankle sprain and 80% of those with a positive history of an ankle sprain had multiple sprains. Most of the injuries were categorized as mild (grade I), but in 32% of the injuries, the athletes missed more than 2 weeks of play. The study showed that no medical attention was sought in 55% of the cases. This means 55% of ankle sprains were left untreated in young athletes, which can lead to residual issues in the ankle later on. About 50% of the athletes with a sprain had residual symptoms from their injuries; 15% of the injured athletes felt that their residual symptoms compromised their playing performance (Olmsted et al., 2004).

Lateral ankle sprains result in multiple acute problems including missed playing time, mechanical and functional instability, weakness, and countless other issues. Injury to the lateral ligamentous complex results in more time lost from participation than any other single sport-related injury (Garrick, 1977). If left untreated or treated poorly, an ankle sprain can develop into a chronic condition. As many as 33% to 42% of lateral ankle sprains exhibit a common and serious residual disability referred to as Chronic Ankle Instability (CAI) (Hale et al., 2014). The American College of Foot and Ankle Surgeons defines CAI as a condition characterized by recurring "giving way of the outer (lateral) side of the ankle," and can occur in the absence of mechanical instability. Hale et al., (2014) states CAI to be a long-term sequela to an ankle sprain injury and is felt by individuals in 20% to 40% of grade II or III diagnosed ankle sprains. By decreasing the chance of obtaining a lateral ankle sprain, CAI and other ankle pathology would therefore also be decreased. By decreasing both of these injuries, athletes would be able to better participate in physical activity on a daily basis, have fewer trips to the athletic training room and overall live a healthier lifestyle by eliminating an acute problem before it becomes chronic. Because of the high rate of ankle injuries, a considerable amount of epidemiologic research has been done to examine the causes and effects of prophylactic methods used to prevent such injuries (Cordova, M.L., Ingersoll, C.D., & Palmieri, R.M., 2002).

Many comparative studies have evaluated the efficacy of different types of external ankle support on ankle-foot range of motion (ROM), functional performance, and various sensorimotor values in subjects with healthy and chronically unstable ankles (Anderson, D.L., Sanderson, D.J., & Henning, E.M., 1995). Ankle taping, lace-up style braces, and semi rigid orthoses are used in an effort to prevent ankle injuries and to stabilize patients who suffer from CAI (Tropp et al., 1985). Through mechanical support offered by ankle bracing and taping, ankle injuries and their frequency rates are shown to be reduced (Cordova et al., 2002). However, increased sensorimotor function offered by external ankle support maybe a contributing factor (Cordova et al., 2002). Cordova et al., (2002) provides a comprehensive review of literature regarding the role of external ankle support on joint kinematics, joint kinetics, sensorimotor function, and functional performance. This study took into review 253 effects from 19 studies published from 1966 through 1997. They found that before exercise, semi rigid braces restricted inversion ROM 21.3% more than tape and 26.2% more than lace-up braces. After exercise, semi rigid braces restricted inversion ROM 72.1% more than tape and 59.5% more than lace-up braces. However, no significant difference existed in inversion ROM restriction between the tape and lace-up brace conditions before (15.9° and 14.9°, respectively) or after exercise (7.3° and 10.6°, respectively). Semi rigid braces provided greater eversion ROM restraint compared with the tape and lace-up brace conditions before (19.8° semi rigid, 9.5° tape, 14.4° lace-up) and after exercise (24.9° semi rigid, 7.1° tape, 8.9° lace-up). When comparing Lace-up to tape based on eversion, lace-up braces provided greater overall eversion ROM restriction (9.8°) than tape (7.2°).

Dorsiflexion ROM was restricted 38.3% more with taping than with a lace-up brace. However, no significant difference existed between tape (9.1°) and lace-up style braces (9.7°) on overall plantar flexion ROM restriction (Cordova et al., 2002).

Findings vary from study to study because of the style of brace used and difference in individual's' skill of tapping. Another key factor of why studies varied can be credited to the methods used for ROM goniometer measurements. When testing the reliability in two methods of goniometer measurements in ankle inversion and eversion, measurements were seen to be high to very high reliability by the same observer within sessions and with low to moderate reliability by different observers within a session (Menadue et al., 2006). In order to maintain consistency in measurements, the same observer had to be kept within each measurement trial rather than changing observer with each measurement. Along with the functional effects of prophylactic ankle bracing, it is important to also understand how postural control is being affected by prophylactic ankle bracing.

Postural control is another key factor in an athlete's ability to prevent injury. Unlike the concrete evidence of the effect of external ankle support have on joint kinematics, the potential effects of external ankle bracing support on a few sensorimotor variables have been studied to a lesser degree. Cordova et al., (2002) conducted a meta-analysis of articles examining external ankle support on sensorimotor function in the peroneus longus and brevis muscles. Peroneus longus (PL) neuromuscular function is critical in dynamically supporting the ankle-foot complex against an inversion mechanism of injury. As a result, PL reaction time, or latency, during a simulated ankle sprain has been studied in normal and chronically unstable ankles. However, the effect of ankle support on PL function has not been studied as extensively (Isakov, E., Mizrahi, J., Solzi, p., 1986). The duration of the PL latency quantified in the studies reviewed by Cordova et al. (2002) involves activation of the group Ia afferent fibers of the muscle spindle located in the muscle belly, which results in an efferent motor response and contraction of the same muscle (Leonard, 1998). Although several prior studies have examined peroneal muscle-reflex temporal characteristics during sudden inversion, this work has used a "quasistatic" model for assessment. A "quasistatic" model takes measurements being done with mimicked loading of the peroneal tendon rather than in a dynamic state like that of a running athlete. Also, the time and amplitude in which the peroneal muscles fire under this condition may not reflect what occurs during an injury. This assessment model may have been used because of methodological difficulties to tract this type of measurement, therefore the use of inversion trap doors and platforms to simulate an ankle injury has been widely accepted. It was noted in one of the earlier studies of external ankle support and leg muscle function by Glick, J. M., and Gordon, R. B., and Nishimoto, D., (1976) that another benefit of taping the ankle, beyond its apparent functional restriction, is the stimulating effect on the peroneus brevis muscle. The study found individuals who suffered from excessive inversion talar tilt and whose ankles were taped initiated peroneus brevis contraction before heel strike during running gait (Glick et al., 1976). This theory suggests a benefit of applying adhesive tape or an ankle brace to be more than just mechanical. When looking at the effects of external ankle support on the PL reflex latency, there is evidence to support adhesive tapes efficacy (Vaes et al., 2002). This reflex reaction time was measured during sudden inversion in subjects with CAI whose ankles were taped. These subjects whom had their ankles taped showed quicker reaction times during rapid inversion compared with those with unsupported condition (Cordova et al., 2002). This shortened reaction time can be credited to helping the lateral ligament complex suffer an injury from solely supporting a full load of sudden inversion in the ankle. Although this study was done decades before today, there is a lack of literature in this area still today.

Static balance, is another proprioceptive measure of balance which has been used to determine differences in individual's postural control. Center of Gravity (COG) is a novel measurement used as an indicator of static balance. Static balance can be defined as the ability to maintain a base of support with minimal movement and dynamically as the ability to perform a task while maintaining a stable position. Factors that influence balance include sensory information obtained from the somatosensory, visual, vestibular systems and motor responses that affect coordination, joint range of motion, and strength (Kaminski, T.W., & Hartsell, H.D., 2002). There are many theories as to what makes some individuals better at balancing than others. Some literature supports superior balance among athletes being the result of repetitive training tasks that influence motor control rather than sensitivity of the vestibular system while others believe it to be the result of training experiences influencing an individual's relevant proprioceptive and visual cues (Bressel, E., Yonker, J.C., Kras, J., & Heath, E.M., 2007). A study by Mettler et al., (2015) showed how a 4-week progressive balance training program helped alter the spatial locations of center of gravity (COG) data points in participants with CAI. Overall, COG position in the balance-training group shifted from being more anterior to less anterior in both eyes-open trials (before trial = 319.1 +/- 165.4, after trial = 160.5 +/- 149.5; P=.006) and a significant difference in eyes-closed trials (before trial=387.9 +/- 123.8, after trial = 189.4 +/- 102.9; P = .001). This shift in COG in the diseased population was considered significant when compared to that of the control group that did not perform balance training. The authors hypothesized that the spatial difference could represent a more constrained sensorimotor system and compensation for postural control in participants with CAI (Pope et al. 2011). Having a more anterior/lateral COG is likely associated with the foot being more supinated, placing the ankle and subtalar joints in a closed-packed and more stable position that decreases feelings of instability (Pope et al. 2011). If a more anterior/lateral trajectory COG is shown with individuals with chronic ankle instability, and a shift from Anterior-Lateral to Posterior-Medial is shown after balance training exercises that matches that of the healthy population, our study may help to understand how ankle bracing may influence COG.

In addition to tracking COG in static situations, postural stability has also been studied within the dynamic setting. The Biodex Balance System is a commercial balance system that consists of a free moving multiaxial platform that provides feedback about COG displacement. Since the Biodex Balance System allows up to 20-degrees of surface tilt, measurements can be taken at the static level or up to level 12 of instability (Arnold, B. L., & Schmitz, R. J., 1998). This type of equipment is useful to clinicians because of its practicality and ability to assess multidirectional postural control in a closed-chain condition. One of the tests that the Biodex offers is the Limits-of-Stability (LOS) test.

This test observes participant’s ability to shift and control their COG within their given base of support. The LOS test uses a movement pattern, shown on a screen in front of subjects, designed to challenge the user to move through the area a person can move (sway envelope). The Biodex outputs are able to measure overall stability index (OSI), anterior/posterior index (APSI), and medial/lateral index scores (MLSI) outputs of the Biodex (Arnold, B. L., & Schmitz, R. J., 1998). Based on the OSI formula used by the Biodex outputs’, MLSI and APSI have equal weights. This means that as APSI declines, MLSI has more effect on the overall stability index. This is important in order to keep consistency in testing trail outputs and establish reliability and validity.

The Star Excursion Balance Test (SEBT) has also been used as a clinical test of dynamic postural control. The SEBT is a way of utilizing lower extremity maximal reach tests while the contra-lateral limb attempts to maintain single-limb balance. In this test, reaching distance serves as a measure of performance and shorter reach distances are typically associated with mechanical or sensorimotor system constraint. Hertel et al., (2006) recommends using the AnteriorMedial (AM), Medial (MD) and PosteriorMedial (PM) directions versus the traditional 8 directions to avoid capturing redundant information. Bressel et al., (2007) compared static and dynamic balance among collegiate female athletes competing in soccer, basketball, and gymnastics. The Balance Error Scoring System (BESS) was used for static balance and SEBT was used to measure dynamic balance. The SEBT scores were 7% higher in the soccer athletes than the basketball athletes. The results concluded no significant difference between gymnasts and the soccer athletes. However, basketball players were inferior in static balance compared to gymnasts and inferior in dynamic balance compared to the soccer athletes. By using the SEBT we can utilize the measurements as a means of seeing how prophylactic ankle braces change individuals reaching scores that correlate directly to limited or changes of range of motion.

Due to the high incidence of lateral ankle sprains and post injury symptoms, sports medicine professionals have implemented prophylactic bracing as a preventative measure for practices and games. Since ankle bracing saves both time and money compared to continuously taping athletes on a daily basis, athletic trainers often use them with incoming freshman and red shirts. Because they're widely used and accepted as a preventative measure, it is critical to understand the long-term effects ankle bracing is having on ankle functionality and balance (static and dynamic) in athletes. Literature has shown the effects of acute ankle bracing on range of motion, but to my knowledge, there is little research that has looked at the effects of longer term (20-weeks) wear on passive ankle range of motion or balance. By looking at passive range of motion measures in the ankle joint over a 20-week span, we can begin to analyze the effects of prophylactic ankle bracing on joint functionality over a period of time rather than just a single bout of exercise.

Purpose/Hypothesis

The purpose of this study was to determine the effect of prophylactic ankle bracing on passive range of motion, static balance (COG displacement, COG pattern tracking over a period of time), dynamic balance (COG displacement in a dynamic setting, COG pattern tracking over a period, reach measures through SEBT) and subjective Foot and Ankle Disability Index / Sport in collegiate women's basketball players across a 20-week season span. We hypothesize that the prophylactic ankle braces will not have a significant effect on the collegiate athlete's passive ankle range of motion, static balance or dynamic balance.

The Specific Aims

1. Analyze the effects of prophylactic ankle bracing on passive joint ROM in ankle dorsiflexion, plantar flexion, eversion, and inversion.
2. Analyze the effects of prophylactic ankle bracing on static balance through the Biodex Postural Stability Test (PST).
3. Analyze the effects of prophylactic ankle bracing on dynamic balance through the Biodex Limits of Stability (LOS) Test, Athletic Single Leg Stability Test (ASL) and the Star Excursion Balance Test.
4. Analyze the effects of prophylactic ankle bracing on subjective symptoms through the Foot and Ankle Disability Index (FADI) / Foot and Ankle Disability Index Sport (FADIS)

CHAPTER 2: METHODS

Subjects

Thirteen female collegiate basketball athletes (21±2 years old) were recruited for this study, with 12 successfully completing all testing. All participants were free of orthopedic and neurological disorders and did not participate in a proprioceptive or balance training program in the six months prior to beginning participation. Athletes on Humboldt states women's basketball team are required to wear ankle bracing during practice and games throughout their season. This made the process of ensuring ankle braces were worn throughout the entire 20-week process easier.

The inclusions criteria for participants included:

1) Be a female collegiate basketball player between the age of 18-25
2) Be free of lower extremity orthopedic injury or neurological disorders in the 6 months prior to the study and also be free of any other physical deficit that limited them in performing the balance testing and team protocols
3) Have no history of concussion or balance disorders in the 6 months prior to the study
4) Have not participated in a proprioceptive or balance specific training activity in the 6 months prior to the study Wear prophylactic ankle bracing assigned to them at the beginning of the season (Don Joy Stabilizing pro ankle brace)
5) Report to scheduled time for baseline, 10-week, 20-week measurements

6) Wear the braces every practice and game pertaining to the HSU basketball schedule.

The exclusions criteria for the participants included:

1) Not in between the ages of 18-25
2) Not a collegiate women's basketball player
3) Had a lower extremity injury in the past 6 months or any other physical deficit that limited them in performing the balance testing and team protocols
4) Had a history of concussion or balance disorders within the last 6 months
5) Had a history of participating in a proprioceptive or balance training activity in the past 6 months

Experimental Design

We measured passive ankle range of motion, static balance (PST), dynamic balance (SEBT, LOS, ASL), and Foot and Ankle Disability Index/Sport at the beginning of the basketball season (Baseline), at mid-season (10-week), and at the end of the season (20-week). Although subjects wore prophylactic ankle braces through all practice and games, measurements were taken with the athletes not wearing ankle braces.

The baseline measures were taken within the first week of the basketball season. The subjects began to practice daily and play games accounting for time in between measurements as the intervention. Prior to participation in the study, all eligible candidates were provided with a verbal and written description of the study. This description covered all aspects of the study including an explanation of the time commitment, confidentiality, procedures, as well as the risks and benefits of the study. Participants were informed that their participation is completely voluntary and that they are free to decline participation at any time during the study. All participants were then required to sign an informed written consent prior to commencement of the study. Along with a consent form, a medical questionnaire was also given to subjects to complete ensuring proper qualifications were met. Demographic information obtained from subjects included height, weight, dominant leg, leg length measurements and foot length/width.

For all experimental testing session including Baseline (0 week), Mid-season (10 week), and End-season (20 week), measurements for this study were collected immediately after practice. This was done to include a fatiguing factor to measurements. Prior to measurement testing, participants were required to ride a stationary bike for 5 minutes at a comfortable pace and low resistance without wearing prophylactic ankle bracing. Following the warm-up, we measured the ROM (Inversion, Eversion, Plantar flexion, and Dorsiflexion) of the candidate's dominant ankle using a goniometer and standard procedures (Willett et al., 2014). Measurements were taken passively and exclusively by Mark Ulbricht, a certified athletic trainer to keep consistency.

Following passive ROM measurements, subjects performed the following three postural balance tests on a Biodex SD (Biodex Balance System SD, Shirley, New York). Trials of each test were given in a randomized counterbalanced order. For the static balance test, subjects performed three 20-second trials of the Postural Stability Test (PST) on a firm surface. Subjects' foot stencils were also used based off their foot length and width measurements with the Biodex trials to ensure consistency in foot placement in between trial periods. Subjects' dominant foot was used as the support leg during the PST. The individual's dominant leg was established through the individual's medical history questionnaire reflecting the "support leg". Our study included subjects who all shared the "Right" leg as their dominant leg. Subjects were instructed to stand as still as possible while focusing on a visual target placed 1 (m) in front of them. Subjects were asked to place their hands on their hips and their contralateral leg to be held at 10 to 20-degree hip flexion and 45 degrees of knee flexion. If subject's contra-lateral leg touched either the ground or stance leg, lost their balance, or moved their hands from their hips, their trial was stopped and redone following a short rest period. PST emphasizes a subject's ability to maintain a center of balance (COB) on a stable surface. Sway is measure as the standard deviation from COB. Along with sway measurements, PST also quantized the location of COB within the foot during the single leg stance trial. The foot was molded into a rectangle with named quadrants; quadrant I (anterior/lateral), quadrant II (anterior/medial), quadrant III (posterior/medial), and quadrant IV (posterior/lateral) (Pope et al. 2011). The PST tracks COB as it moves within the quadrants and calculates a percentage value for the overall time COB was within the quadrant through the 20-second trial.

Prior to performing the Star Excursion Balance Test (SEBT), Participants were given instructions on how to properly complete the Star Excursion Balance Test (SEBT). Subjects then performed one familiarization trial of the SEBT prior to performing the experimental trial. For both the familiarization and experimental trials of the SEBT, subjects stood barefoot at the center of a grid laid on the floor with 8 lines extending at 45-degree increments from the center of the grid. Subjects' dominant foot was used as there "stance leg," which was used to support individuals as they used their non-dominant leg to reach out. The length and width of the stance foot was used to create a stencil, which was used to place subjects' foot over the same position on the SEBT throughout the different measurements to ensure consistency. This placed the dominant leg geometric center positioned in the middle of the grid where a cross hair intersected the center of the foot. Subjects placed their hands on their hips and maintained a single leg stance, while reaching with the contralateral leg to touch as far as possible along the chosen line. The reach foot touched the furthest point on the line as lightly as possible so that the reach leg did not provide considerable support in the maintenance of upright posture. Subjects then returned to a bilateral stance while maintaining equilibrium. Distance (centimeters) was recorded in the Anterior Medial (AM), Medial (MD), and Posterior Medial (PM) directions. Subjects reach distances will be normalized by each subject's leg length. Leg length was measured as distance (centimeters) from the anterior superior iliac spine to the distal tip of the medial malleolus of the dominant leg.

Further measurements of dynamic balance included the Limits of Stability (LOS) and Athletic Single Leg Stability Test (ASL). LOS measurements tested subject's ability to accurately move a display cursor to a target ten degrees from a level platform and back again. This was done to see how well subjects can control their Center of Gravity (COG) over base of support. The test measured overall time (sec), overall scores (average score of 8 directional scores out of 100), and specific direction (forward, left, right, backward, forward/left, forward/right, backward/left, backward/right) scores (out of 100). The overall scores and direction scores are considered directional control score percentages. This score is derived by dividing the straight-line distance to the target by the actual distance traveled by the subject. This is then multiplied by 100 to give a percentage output (directional control score). During each test trial, subjects were required to shift their weight in order to move a cursor on the screen in front of them. This central reference point had to be moved towards one of the blinking targets and to return to the central point as quickly and with as little deviation as possible. The cursor had to stay and blink with the target box for 0.25 seconds before it displaced the next target box on the screen. The same procedure was repeated for each of the eight targets on the screen, which blink in random order. The LOS shared the same instructions as the PST and ASL when categorizing a failed trail and qualifications for retrial. Like the PST, the ASL test emphasized a subject's ability to maintain a center of balance (COB). However, this test was done on an unstable surface. Three 20-second trials were done per measurement date. Platform instability was set to "12," which indicated maximal instability of the platform with 10 degrees or motion possible. The ASL also noted the standard deviation from COB and quantized the location of COB within the foot in the same manner as the PSL output.

Finally, we used both the Foot and Ankle Disability Index (FADI) and Foot and Ankle Disability Index Sport (FADIS) to subjectively quantize how subjects felt through the course of the 20-week season. The questionnaire was given to subjects after their measurements were completely done as the final step in measurements before finishing the given testing period.

Statistical Analysis

A one-way Repeated Measures Analysis of Variance (ANOVA) was used to examine changes in range of motion and balance over the course of a 20-week basketball season (SPSS Version 25.0, Chicago, IL). In this study, time of prophylactic ankle brace use was the independent variable. The three points of measurements (Baseline, 10-week, 20-week) were considered our three levels of time. The six tests used for measurements: Range of Motion (ROM), Postural Stability Test (PST), Star Excursion Balance Test (SEBT), Athletic Single Leg Stability Test (ASL), Limits of Stability (LOS), Foot and Ankle Disability Index (FADI), Foot and Ankle Disability Index Sport (FADIS), were considered the dependent variables. Six separate ANOVA's were performed on each set of dependent variables: ROM (inversion, eversion, plantarflexion, dorsiflexion), Postural Stability Test (standard deviation from center of balance, displacement range in center of gravity), Star Excursion Balance Test (anterior/medial, medial, and posterior/medial direction), Athletic Single Leg Stability Test (standard deviation from center of balance, displacement range in center of gravity), Limits of Stability Test (control of individuals center of gravity over base of support), and Foot and Ankle Disability Index / Foot and Ankle Disability Index Sport (subjective Likert scale questionnaire of ankle symptoms throughout the season). When warranted, we used with-in subject post-hoc T-test with

Bonferroni adjustments to identify specific differences between time points. The alpha level for determining significance was set at ≤ .05 for all statistical analyses.

Assumptions and limitations

- Assumptions for this study include those associated with our statistical analysis (no outliers in our data, homogeneity of variance and normality, sphericity in variance)
- We assume that the athletes answered the history questionnaire honestly
- It was assumed that the participants wore their ankle braces to every practice and game they participated in
- We assume subjects properly wore the ankle braces as instructed in the beginning of the study
- We collected our baseline measurement during Humboldt State Women's Basketball first week of the season, however, the participants had already been wearing the ankle braces and had been training for 4-6 weeks prior to the start date

Delimitations

- Only female collegiate basketball players (age: 18-25 years) were used as participants
- Only "Right" dominant foot athletes were looked at in this study
- Lack of control group to make comparisons
- Measurements were only taken after practice

- Covariate factors like neural activation levels or strength of lower leg muscles will not be looked at in this study
- Only Donjoy Stabilizing pro ankle brace type of prophylactic ankle bracing will be used in the study
- The use of a standard goniometer instead of a dynamometer to make passive ROM measurements precise
- Athletes wore prophylactic ankle braces during offseason training prior to baseline measurements done at the beginning of their season

CHAPTER 3: RESULTS

Descriptive Statistics

Twelve participants completed the study. A total of 13 women's basketball players were screened and started the study, with one having to drop out due to injury. All participants shared right foot dominance when being screened. Other demographic and anthropometrical characteristics of the subjects are provided below (Table 1).

Table 1. Descriptive Statistics

Subjects (n)	Age (yrs)	Height (cm)	Weight (kg)	Foot Length (cm)	Dominant Foot
12	21±2	168.5±8.2	69.27±7.75	24.7 ± 1.2	100% Right

Range of Motion (ROM)

In contrast to our hypothesis, passive ankle eversion ROM decreased (p = .004, Table 2) and increased plantarflexion ROM increased (p = .001, Table 2) over a 20-week period of wearing prophylactic ankle bracing during the sporting season. Post hoc tests show that eversion ROM was similar from baseline to the 10-week mark (P>.05) but decreased by 8.75% across the 10-week to 20-week period (p =.023, Table 2). Interestingly, plantarflexion ROM increased 33.7% over the first 10-weeks of the study (Baseline to 10 weeks) (p =.001). While plantarflexion ROM remained 21% greater than baseline after 20-weeks of using the ankle bracing (p = .020), it did not increase over the last 10-weeks (P>.05, Table 2). Although we observed no significant main effect of time on passive inversion angle over the 20 weeks period (*p* =.079, Table 2), passive ankle inversion decreased by 10% by mid-season (10-weeks) (*p* = .046) and 12% by the end of the season (*p* = .027) when compared to baseline. Time intervention did not lead to any statistically significant changes in ankle dorsiflexion ROM (p=.173).

Table 2. Means and SEM of ankle ROM (Degrees)

	Beginning (Baseline)	Mid-Season (10 Weeks)	End (20 Weeks)	Time Main Effect
Inversion	49.75 ± 1.42	44.75 ± 2.27*	43.67 ± 2.34*	P = .079
Eversion	42.83 ± 1.89	52.67 ± 2.05	43.92 ± 1.76†	P = .004
Plantarflexion	48.75 ± 2.42	65.17 ± 2.81*	58.83 ± 1.96	P = .001
Dorsiflexion	13.17 ± 0.77	10.67 ± .01	10.67 ± 1.06	P = .173

(*) Indicates significant change from Baseline (P<.05).
(†) Indicates significant change from mid-season to end of season (P<.05).

Static Balance

Postural stability

In contrast to our hypothesis, there was an overall decrease in the Postural Stability Test scores over time (*p* = .035, partial η^2 = .978, Table 3). Scores decreased in the first 10-weeks by 27% (*p* = .012, Table 3) but did not change any further in the second half of the season (10-20 weeks) (*p* >.05).

Table 3. Means and SEM of the Postural Stability Test (PST)

	Beginning (Baseline)	Mid-Season (10 Weeks)	End (20 Weeks)	Time effect
Anterior/Posterior	.6578 ±.1115	.4785 ±.0467	.4769 ±.0537	P = .091
Medial/Lateral	.7062 ±.1334	.5164 ±.0881	.6145 ±.1634	P = .264
Overall	1.100 ±.1528	.8023 ±.0978*	.8766 ±.1688	P = .035

(*) Indicate a significant difference from Baseline (*p*<.05)

Dynamic Balance

Star excursion balance test

In support of our hypothesis, there was no significant effect of time wearing ankle bracing for the Anterior/Medial and Medial directions of the Star Excursion Balance Test (p = .764 and p = .279, respectively). However, Postural stability in the Posterior/Medial direction increased 8.8% over the 20-week study (p = .036, Table 4).

Table 4. Means and SEM of normalized SEBT (cm)

	Beginning (Baseline)	Mid-Season (10 Weeks)	End (20 Weeks)	P-Value
Anterior/Medial	80.36 ± 2.11	81.46 ± 1.71	80.19 ± 1.34	P = .764
Medial	81.09 ± 2.16	84.99 ± 2.20	83.25 ± 1.96	P = .279
Posterior/Medial	80.97 ± 2.31	87.07 ± 2.83	88.10 ± 2.03	P = .036*

(*) Indicates overall significance from beginning versus ending measurements ($P<.05$)

Limits of stability test

In contrast to our hypothesis, overall Limits of Stability Test time decreased over the 20-week season (p = .007, Table 5). Specifically, overall LOS time decreased by 12% after the first 10 weeks (p = .005) and 18% by the end of the season (p = .015) when wearing prophylactic ankle braces. In contrast, Limits of Stability Test scores in the left direction increased 65% from Baseline to mid-season (p = .001, Table 5) but did not change between the mid-season and the end of the season (p = .117). Likewise, the LOS in the backward/left direction increased 37% during the first 10 weeks (p = .017, Table 5) but did not change significantly after this time point (p =1.00). While LOS scores in the backward direction increased over the entire 20-weeks of the study, we only observed a significant change in backward LOS scores in the first 10-weeks of the season by 31% (*p* =.003).

Table 5. Means and SEM of the Limits of Stability Test (LOS)

	Beginning (Baseline)	**Mid-Season (10 Weeks)**	**End (20 Weeks)**	**Time Main Effect**
Overall	32.67 ± 2.14	40.67 ± 1.60*	40.42 ± 2.51	P = .001
Forward	43.25 ± 3.54	52.50 ± 4.82	54.08 ± 4.23	P = .133
Backward	42.92 ± 3.99	53.42 ± 3.02	56.42 ± 3.15†	P = .003
Right	43.50 ± 3.74	48.67 ± 3.96	50.67 ± 4.40	P = .412
Left	33.50 ± 2.63	55.42 ± 4.54†	43.92 ± 3.40	P < .0001
Forward/Right	37.42 ± 3.84	40.33 ± 3.09	44.33 ± 3.79	P = .290
Forward/Left	33.50 ± 3.99	38.83 ± 3.82	33.75 ± 2.92	P = .482
Backward/Right	38.25 ± 3.47	38.17 ± 2.93	44.33 ± 3.79	P = .330
Backward/Left	32.92 ± 4.00	45.00 ± 2.88†	42.50 ± 3.84	P = .015
Time (s)	68.25 ± 3.35	60.08 ± 2.17†	56.08 ± 1.43	P = .007

(*) Indicates significantly difference scores in LOS score compared to Baseline
(†) Indicates a significant change in scores from mid-season (10 weeks) to end of season (20 weeks). Significance is set at p<.05.

Athletic stability single leg test

In support of our hypothesis, there were no significant differences in the means sway velocity during the Athletic Single Leg Stability Test as a result of wearing prophylactic ankle braces over a 20-week period (*p* =.097). Similarly, the sway velocity variability (SD of sway) did not change over this same 20-week time period (*p* =.330). Upon further analysis, we observed that sway velocity variability in the anterior/lateral direction decreased across the 20-weeks of the study (*p* = .025).

Table 6. Means and SEM of the Athletic Single Leg Stability Test (ASL)

	Beginning (Baseline)	Mid-Season (10 Weeks)	End (20 Weeks)	Time Main effect
Anterior/Lateral	32.42 ± 5.63	26.58 ± 3.39	16.83 ± 2.25*	P = .016
Anterior/Medial	12.50 ± 2.66	13.50 ± 3.41	8.08 ± 1.55	P = .288
Posterior/Medial	19.00 ± 4.57	19.08 ± 4.72	23.25 ± 4.26	P = .607
Posterior/Lateral	36.08 ± 4.33	40.83 ± 4.39	51.58 ± 5.50	P = .066

(*) Indicates a significant change as compared to Baseline (P<.05).

Foot and Ankle Disability Index

We observed no differences in the subjective Foot and Ankle Disability Index (FADI) / Foot and Ankle Disability Index Sport (FADIS) questionnaire as a result of wearing prophylactic ankle bracing over the 20-week basketball season.

Table 7. Means and SEM of the (FADI) / (FADIS)

	Beginning (Baseline)	Mid-Season (10 Weeks)	End (20 Weeks)	Time Main Effect
FADI	95.08 ± 2.45	98.83 ± 1.78	95.50 ± 13.01	P = .058
FADIS	28.75 ± 0.92	29.17 ± 0.86	28.58 ± 1.08	P = .774

No significant differences observed as compared to Baseline (P<.05).

CHAPTER 4: DISCUSSION AND CONCLUSION

Discussion

The purpose of this study was to examine the effects of prophylactic ankle bracing on passive range of motion, static balance, and dynamic balance in collegiate women's basketball players across the span of a 20-week season. This study rejected the null hypothesis and found differences in ROM, increases in Postural Stability, and improvements with Limits of Stability (LOS) scores. This study also found a significant decrease in the anterior/lateral quadrant of the ASL test which suggests a change in COG placement over the 20-week span of the season.

Range of Motion

Due to the lack of literature addressing the effect of athletic participation time on passive ankle ROM, a standard in ROM deviations over time has not been established. To our knowledge, no study has investigated the effects of chronic prophylactic ankle bracing on non-braced range of motion. Cordova did observe that semi rigid braces restricted inversion ROM 72.1% more than tape and 59.5% more than lace-up. Although our study looked at no-braced ROM, we did observe that following 20 weeks of wearing ankle braces, inversion ROM decreased. This may be due to the overall mechanics of prophylactic ankle braces when worn correctly. Ankle braces pull from the medial to lateral direction, which helps protect the weaker lateral ligament complex of the ankle (Hale et al., 2014). As seen with Glick et al (1976) excessive inversion talar tilt in those whose ankles were taped or wore prophylactic ankle braces initiated peroneus brevis contraction before heel strike during running gate. Additionally, some researchers have shown no changes in peroneus longus (PL) latency after the application of prophylactic ankle support. Healthy subjects showed no change in PL reflex latency with ankle support before or after exercise (Cordova et al., 2000). Additionally, Cordova et al (2000) reported that PL reaction time remained unaffected by a sudden inversion drop immediately after the application of a lace-up or semi rigid ankle brace. These findings can be viewed as supporting the use of external ankle bracing. Since external ankle support does not affect the latency of the reflex circuitry of the muscle spindles within the PL, the ankle is able to combat sudden inversion and therefore help the weak lateral ligaments complex and avoid injury.

Since our measurements were taken after a typical practice day, this may have exhausted the muscles that work on limiting inversion during passive ROM. Increased ROM in the beginning 10 weeks could have been due to fatigue of the peroneal muscles which help stabilize in sudden inversion and inversion/plantarflexion movements (Glick et al., 1976). Furthermore, the following 10 weeks after mid-season measurements could lead to decreased eversion ROM due to the adjustment of the eversion muscles and medial stabilizers (Loram et al., 2004).

Static Balance

Similar to our ROM measures, wearing prophylactic ankle bracing showed a decrease in PST scores and thus improved balance over the course of the first 10 weeks of the study. However, static balance did not improve in the last 10 weeks of the study. This may be related to adjustments made by lower leg muscles to stabilize the body from the stress produced during the first 10 weeks of basketball participation. This includes peak scores in PST, suggesting that there may be a peak in center or gravity control within a period of a 20-week season. Because the improvement in PTS scores signify improved balance they may also suggest a decreased chance in injury. Postural control performance accounted for approximately 20% of the variance in increased injury risk in a study done by Wang et al, (2006). However, having poor postural control performance was established as the best predictor of ankle sprains. Wang's group used center of pressure (COP) excursion measures and did identify an increased risk of ankle sprain in those with poorer postural stability scores. The COP measures appeared to be more sensitive in detecting postural control impairments in those at increased risk of ankle sprain (Wang et al, 2006). Other factors which may be related to the difference in improvement of static balance between the first 10 weeks of the study include adjustments in the type of practice and weight lifting done by the subjects. As the season moves on, practices tend to shorten up and lifts become easier. This is done in an attempt to reduce injuries, fatigue and burn out in individuals playing a whole season. (Anderson et al., 2004).

Dynamic Balance

Based on our observation, the 20-week intervention showed an improvement in dynamic stability of 7.1% in the posterior/medial direction which compliments what we saw with the Limits of Stability (LOS) test scores. More specifically, both of these tests revealed improving scores over the first 10 weeks in the posterior/medial direction. The LOS test uses visual cues to lead the patient in the direction that is prescribed on the screen. Moreover, the SEBT looks at maintaining center of mass over base of support which allows hip and knee flexion where the LOS test limits hip and knee flexion. Nonetheless, improved scores in both the LOS and SEBT posterior/medial direction may be connected through learned outcomes of the testing trials.

We did not observe differences in means or variability of the ASL test, but we did see a change on the location of the center of gravity toward the anterior/lateral quadrant. When looking at COG in a diseased population vs. a healthy population, literature shows a displacement of COG in the anterior/lateral quadrant of the foot in the disease population where healthy individuals showed more posterior/lateral displacement. Having a more anterior lateral COG is likely associated with the foot being more supinated, placing the ankle and subtalar joints in a closed-packed and more stable position that decreases feelings of instability (Pope et al. 2011). If a more lateral trajectory COG is shown with individuals with chronic ankle instability, and a decreasing shift from Anterior-Lateral is seen from our study, prophylactic ankle bracing may be helping correct unknown deficiencies looming with our subjects. Even though our subjects were all considered healthy at the start of our study, a significant decrease in displacement stationed in the anterior/lateral quadrant was observed. In contrast, an increase in displacement stationed in the posterior/lateral quadrant was seen, however, it was not statistically significant.

Foot and Ankle Disability Index / Sport

The foot and ankle disability index has often been used to identify symptoms related to the health and stability of the foot and ankle. An added section of this measure pertaining to sports participation is also used when warranted. The FADI/FADIS has been shown to be both valid and reliable in detecting functional limitations in subjects with chronic ankle instability, sensitive to differences between healthy subjects and subjects with chronic ankle instability and is responsive to improvements in function after rehabilitation in subjects with chronic ankle instability (Hale, S. A., & Hertel, J, 2005). Even though we found no significant changes in FADI/FADIS scores following 20 weeks of wearing prophylactic ankle bracing, our finding may be clinically important. Often times, athletes claim prophylactic ankle bracing or taping makes their ankles feel weaker and less stable when not wearing the braces. By showing no change in the subjective FADI/FADIS scores, this study may help the athletic community understand the true positive and negative outcomes of wearing ankle braces over a period of time.

Limitations and Direction of Further Research

One limitation to this study is the lack of variability in athletes tested and number of subjects tested. Our study focused on women's basketball players due to adherence and simplicity. Furthermore, these subjects all shared a common right foot dominance. Basketball players rely heavily on ankle strength, ROM, and proprioception. Based on the results of this study and others, a significant decrease in inversion/plantarflexion was seen along with an increase in eversion. Future studies looking at ROM, static balance and dynamic balance in individuals may warrant the use of EMG on lower leg muscles to distinguish differences seen in muscle activation acting upon joint functionality. This could provide insight into the activation differences throughout the period of trials and relate activation levels to PL latency. Frequency measures used by the Biodex may also be considered limitations of this study. Postural sway variables from a force platform have often been considered the "gold standard" for measuring static balance because of its ability to measure at a fast rate and with high precision (Riemann, 1999). Although no gold standard has been defined for dynamic balance, more sophisticated techniques such as the Dynamic Postural Control Index (Wilstrom et al., 2005) and the time-to-stabilization test are available (Hertel et al., 2006). Accordingly, a variety of balance tests exist and we therefore chose tests that are considered reliable and valid (Riemann, 1999). Practically, the postural and dynamic exams performed on the Biodex require minimal equipment and are clinically "friendly," particularly when conducted with fewer trials or reach directions (Arnold, B. L., & Schmitz, R. J. 1998). Moreover, additional time point measurements would help distinguish when exactly ROM may have reached its peak and when individual test may have begun to have an inverse effect.

Conclusion

The results of this study indicated that wearing prophylactic ankle braces over a period of a 20-week season produces shifts in ROM, center of gravity and overall postural control. Although most differences were seen within the first 10 weeks, this study suggests researchers should further explore the effects of prophylactic ankle bracing over longer periods of time rather than just in the acute setting. Although our study does not develop an overall correlation in trends, clear findings are established within ROM, static balance, and dynamic balance when it comes to the use of bracing over the course of a season. Athletes using prophylactic ankle bracing showed a decrease in inversion/plantarflexion which can be seen as a benefit in reducing ankle injuries due to the mechanism of injury pertaining to the weak lateral complex ligaments. Furthermore, a decrease in center of gravity from the anterior/lateral location and increased postural stability scores also support the use of prophylactic ankle braces. In addition, our findings provide a fundamental understanding of the potential effects of ankle bracing on static and dynamic balance in female basketball players over the course of a season.

The clinical significance of this study positively supports the use of prophylactic ankle braces in healthy individuals. Our study adds an insight in a proper shift in center of gravity from that mimicked in diseased individuals to more of that of the healthy population. This study will add to the body of knowledge that will allow coaches, athletic trainers, and fitness professionals to make evidence-based decisions on how to prepare individuals who will wear ankle braces through their athletic careers. The measuring of ROM, postural stability and FADI/FADIS scores in collegiate women's basketball players over a period of 20-weeks showed positive and negative difference through this study. This signifies a need for more research to be done in the wearing of prophylactic ankle bracing for long periods of time.

REFERENCES

1. Anderson, D. L., Sanderson, D. J., Henning, E. M. (1995). The Role of External Nonrigid Ankle Bracing in Limiting Ankle Inversion. *Clinical Journal of Sport Medicine.* (5), 18–24.

2. Arnold, B. L., & Schmitz, R. J. (1998). Examination of Balance Measures Produced by the Biodex Stability System. *Journal of Athletic Training*, 33 (4), 323–327.

3. Bressel, E., Yonker, J. C., Kras, J., & Heath, E. M. (2007). Comparison of Static and Dynamic Balance in Female Collegiate Soccer, Basketball, and Gymnastics Athletes. *Journal of Athletic Training*, 42 (1), 42–46.

4. Chaudhry, H., Findley, T., Quigley, K. S., Ji, Z., & al, e. (2005). Postural stability index is a more valid measure of stability than equilibrium score. *Journal of Rehabilitation Research and Development*, 42 (4), 547-56.

5. Christopher, R., Carcia, R., Martin L. R., & Drouin, M. D. (2008). Validity of the Foot and Ankle Ability Measure in Athletes with Chronic Ankle Instability. *Journal of Athletic Training*, 43, (2), 179-183.

6. Cordova, M. L., Ingersoll, C. D., & Palmieri, R. M. (2002). Efficacy of Prophylactic Ankle Support: An Experimental Perspective. *Journal of Athletic Training*, 3 (4), 446–457.

7. Cordova, M. L., Cardona, C. V., Ingersoll, C. D., Sandrey, M. A. (2000). Long-term ankle brace use does not affect peroneus longus muscle latency during sudden inversion in normal subjects. *Journal of Athletic Training*, 3, 407–411.

8. Garrick, J. G. (1977). The Frequency of Injury, Mechanism of Injury, and Epidemiology of Ankle Sprains. *American Journal of Sports Medicine. 5* (6), 241–242.

9. Glick, J. M., Gordon, R. B., & Nishimoto, D. (1976). The Prevention and Treatment of Ankle Injuries. *American Journal of Sports Medicine.* (4), 136–141.

11. Hale, S. A., Fergus, A., Axmacher, R., & Kiser, K., (2014). Bilateral Improvements in Lower Extremity Function after Unilateral Balance Training in Individuals with Chronic Ankle Instability. *Journal of Athletic Training, 49* (2), 181-191.

12. Hale, S. A., & Hertel, J. (2005). Reliability and Sensitivity of the Foot and Ankle Disability Index in Subjects with Chronic Ankle Instability. *Journal of Athletic Training*, *40* (1), 35–40.

13. Hertel, J., Braham, R. A., Hale, S. A., & Olmsted-Kramer, L. C. (2006). Simplifying the Star Excursion Balance Test: Analyses of Subjects with and without Chronic Ankle instability. *The Journal of orthopedic and sports physical therapy*, 36 (3), 131.

14. Hertel, J., Miller, S. J., & Denegar, C. A. (2000). Intratester and Interstater Reliability during the Star Excursion Balance Tests. *Journal of Sport Rehabilitation*, 9 (2), 104-116.

15. Hertel, J., & Olmsted-Kramer, L. C. (2007). Deficits in Time-To-Boundary Measures of Postural Control with Chronic Ankle Instability. *Gait & posture, 25* (1), 33-39.

16. Hertel, J., Olmsted-Kramer, L. C., & Challis, J.H. (2006). Time-To-Boundary Measures of Postural Control during Single Leg Quiet Standing. *Journal of applied biomechanics*, 22 (1), 67.

17. Isakov, E., Mizrahi, J., Solzi, P. (1986). Response of the Peroneal Muscles to Sudden Inversion of the Ankle during Standing. *Int J Sport Biomech,* 2, 100–109.

18. Kaminski, T. W., & Hartsell, H. D. (2002). Factors Contributing to Chronic Ankle Instability: A Strength Perspective. *Journal of Athletic Training*, *37* (4), 394–405.

19. Loram, I. D., Maganaris, C. N., & Lakie, M. (2004). Paradoxical muscle movement in human standing. *The Journal of Physiology*, *556* (3), 683–689.

20. Leonard C T. Mosby; St Louis, MO: 1998. The Neuroscience of Human Movement.

21. Lin, C. W. C., Hiller, C. E., & de Bie, R. A. (2010). Evidence-based treatment for ankle injuries: a clinical perspective. *The Journal of Manual & Manipulative Therapy, 18* (1), 22–28.

22. Menadue, C., Raymond, J., Kilbreath, S. L., Refshauge, K. M., & Adams, R. (2006). Reliability of two goniometric methods of measuring active inversion and eversion range of motion at the ankle. *BMC Musculoskeletal Disorders,7* (1).

23. Mettler, A., Chinn, L., Saliba, S. A., McKeon, P. O., & Hertel, J. (2015). Balance Training and Center-of-Pressure Location in Participants with Chronic Ankle Instability. *Journal of Athletic Training, 50* (4), 343–349.

24. Olmsted, L. C., Vela, L. I., Denegar, C. R., & Hertel, J. (2004). Prophylactic Ankle Taping and Bracing: A Numbers-Needed-to-Treat and Cost-Benefit Analysis. *Journal of Athletic Training*, *39* (1), 95–100.

25. Pope, M., Chinn, L., Mullineaux, D., McKeon, P.O., Drewes, L., Hertel, J. (2011). Spatial Postural Control Alterations with Chronic Ankle Instability. *Gait Posture*, 34 (2), 154–158.

26. Riemann, B. L., Guskiewicz, K. M., & Shields, E. W., (1999). Relationship between clinical and forceplate measures of postural stability. *Journal of Sport Rehabilitation*. 8, 71–82.

27. Smith, R. W., & Reischi, S. F. (1986). Treatment of Ankle Sprains in Young Athletes. *The American Journal of Sports Medicine, 14* (6), 465-471.

28. Tropp, H., Askling, C., & Gillquist, J. (1985). Prevention of Ankle Sprains. *The American Journal of Sports Medicine, 13* (4), 259-262.

29. Wang, H. K., Chen, C. H., Shiang, T. Y., Jan, M. H., Lin, K. H., (2006). Risk-factor analysis of high school basketball-player ankle injuries: a prospective controlled cohort study evaluating postural sway, ankle strength, and flexibility. *Arch Phys Med Rehabilitation.* 87 (6), 821-825.

30. Wikstrom, E. A., Tillman, M. D., Smith, A. N., Borsa, P. A., (2005). A new force-plate technology measure of dynamic postural stability: the dynamic postural stability index. *Journal of Athletic Training,* 40, 305–309.

31. Wiley, J. P., & Nigg, B. (1996). The Effect of an Ankle Orthosis on Ankle Range of Motion and Performance. *Journal of Orthopedic & Sports Physical Therapy, 23*(6), 362-369.

32. Willett, K., Keene, D. J., Morgan, L., Gray, B., Handley, R., Chesser, T., & Lamb, S. E. (2014). Ankle Injury Management (AIM): design of a pragmatic multi-center equivalence randomized controlled trial comparing Close Contact Casting (CCC) to Open surgical Reduction and Internal Fixation (ORIF) in the treatment of unstable ankle fractures in patients over 60 years. *BMC Musculoskeletal Disorders, 15* (1).

33. Winter, D.A., Patla, A.E., & Frank, J.S. (1990). Assessment of Balance Control in Humans. *Med Prog Technol, 16* (1-2), 31-51.

34. Vaes, P., Duquet, W., & Van Gheluwe, B. (2002). Peroneal Reaction Times and Eversion Motor Response in Healthy and Unstable Ankles. *Journal of Athletic Training, 37* (4), 475–480.

35. Van Emmerik, R. E. A., & Van Wegen, E. E. H. (2002). On the Functional Aspects of Variability in Postural Control. *Exercise and sport sciences reviews*, 30 (4), 177-183.

APPENDIX

Consent Form

The Effect of Prophylactic Ankle Bracing on Collegiate Woman's Basketball Ankle Range of Motion, Static Balance and Dynamic Balance

Principal Investigator: Damian Aguilar, ATC, B.S.
(Approval Date: 10/16/2017)

PARTICIPANT INFORMED CONSENT FORM

Please read the following material that explains this research study. Signing this form will indicate that you have been informed about the study and that you want to participate. We want you to understand what are you are being asked to do and what risks and benefits are associated with the study. This should help you decide whether or not you want to participate in this study.
You are being asked to participate in a research project conducted by Damian Aguilar, ATC under the supervision of Justus Ortega, Ph.D., Department of Kinesiology and Recreation Administration, 1 Harpst St., Arcata, CA, 95521. **Dr. Justus Ortega, may be reached at (707) 826-4274 or jdo1@humboldt.edu to answer any questions or concerns.**

Project Description:

Although there is extensive research in pre/post effects of ankle bracing on ROM, static balance and dynamic balance no literature is currently present to my knowledge on observing the effects of prophylactic ankle bracing in collegiate athletes over a period of time. Present literature is inconclusive in deciding a significant finding because of different covariates. Many vary due to type of bracing used, methods of ROM measurement and all together individual error in methods. Because they're widely used and accepted, it is critical to understand the effects ankle braces are having on ankle functionality and proprioceptive factors The purpose of this study was to determine the effect of prophylactic ankle bracing on passive range of motion, static balance (COG displacement, COG pattern tracking over a period of time), and dynamic balance (COG displacement in a dynamic setting, COG pattern tracking over a period, reach measures through SEBT) in collegiate women's basketball players through a season. You are being asked to be in this study because you are 18-25 years of age and in good health. Participation in this study is entirely your choice.

Procedure:

If you agree to take part in this study, you will be asked to come to the athletic training room/biomechanics laboratory for four experimental sessions. There is no monetary compensation for participation in this study. All experimental sessions will take place in the HSU Biomechanics Lab and the athletic training room.

Orientation and Baseline Session in Athletic Training Room (45 minutes)

- I will explain the study and what we will ask you to do.
- You will read the informed consent.
- I will answer any questions you may have.
- You will sign the informed consent form, if you agree to participate in the study.
- You will complete a medical history questionnaire
- You will perform warm up for 5 minutes at a comfortable pace on a stationary bike
- I will measure your foot length and width.
- You will perform the Star Excursion Balance Test twice as a base measurement. (One time as a trail and the second for a measurement)
- Your ankle Inversion, Eversion, Plantar flexion and Dorsi flexion will be measured.
- Your leg length will be taken on your dominant leg
- We will then head to the biomechanics lab to take measurements on the Biodex

Biodex measurements in the Biomechanics Session (about one hour thirty minutes)

- You will be instructed on how measurements will be taken
- We will take three measurements for The Postural Stability Test (PST)
- We will take three measurements for The Limits of Stability Test (LOS)
- We will take three measurements for The Athletic Single Leg Stability Test (ASL)

These measurements will be repeated for total of four times. Measurements will be taken at:

1) Baseline mark (first week of practice)
2) Middle of season (week of December 11th)

3) End of season (week of February 19th)

Participation in this study should take approximately 5 hours and fifteen minutes' total time. The total time commitment is broken up as follows; orientation (45 minutes), and experimental trials (45 minutes to 1 hour and 15 minutes per day [2 days]).

A maximum of 20 participants will be invited to participate in this research study.

Risks and Discomforts:
Since there will be no explosive movements or aggressive mobility, there is a small chance of injury. Since the candidate will be actively standing on one foot for the center of pressure and time to balance measurements, there is a slight chance of injury to the candidate's ankle if hyper inversion or hyper eversion happens at the testing point. Moreover, the members of our research team that will be conducting this experiment are all CPR and first aid certified and will provide constant supervision as an additional safety precaution. Aside from these risks, none of the other procedures should cause you discomfort or injury.

Benefits:
The benefits to the subjects for participating in this study include: (a) knowledge of variation in kinematics of the ankle given the results, (b) discrepancies that could be found from the data given per individual.

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

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

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

Confidentiality:
We will make every effort to maintain the privacy of your data. From the beginning of your participation, you will be given a unique identity code. This code will be used instead of your name for all documentation of your participation. We will keep your

individual data and results confidential including computer files, paper files, and any personal information. In written or oral presentations of the results of this research, your identity and individual information will be kept confidential. After the project is complete, the materials associated with the project, including computer files, paper files, and personal information will be secured in a locked cabinet in a locked office under the supervision of Dr. Justus Ortega for five years in case there is a need for future verification or reanalysis of the data. Upon completion of this informed consent form, you will receive a signed copy of the consent form. Other than the research team, only regulatory agencies, such as the Humboldt State University Committee for the Protection of Human Subjects in Research may see your individual data as a part of routine audits.

Invitation for Questions:
If you have questions about this study, you should ask the researcher before you sign this consent form. **You may also contact Damian Aguilar, ATC, the Primary Investigator to answer any questions or concerns regarding the study at dia8@humboldt.edu or (209) 648-3438.**
If you have any concerns with this study or questions about your rights as a participant, contact the Institutional Review Board for the Protection of Human Subjects at irb@humboldt.edu or (707) 826-5165.

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

Name of Participant (printed) ____

Signature of Participant________________________________ Date _________________
(Also, initial all previous pages of consent form)

Medical History Form

Name: ___________________________
Date of Birth / Age: _______________
Dominant Hand: __________________
Dominate Foot:___________________

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

Please answer the following questions.

1. **Have you worn ankle braces before starting this year's basketball season? (If yes, where and when did you start wearing them and for how long?)**

2. **What day did you start wearing ankle braces this year?**

3. **What day did you start training for this basketball season?**

4. **Please check the appropriate response for each question.**

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

Item #:	**In the past 6 months, have you ever had or do you currently have:**	**Response:**	**Details (specific information, dates, brief explanations):**
7	Injury to abdomen, chest or ribs?	Yes / No	When? Diagnosis:
8	Injury to hip/pelvis?	Yes / No	When? Right? left? both? Diagnosis:
9	Injury to knee?	Yes / No	When? Right / Left / Both
10	Injury to ankle/foot/leg?	Yes / No	When? Right / Left / Both Diagnosis:
11	Injury to face/eye/nose?	Yes / No	When? Diagnosis:
12	Stress Fractures?	Yes / No	Body part:

Item #:	**In the past 6 months, have you ever had or do you currently have:**	**Response:**	**Details (specific information, dates, brief explanations):**
14	Recent surgeries?	Yes / No	If yes, please explain:
15	Do you currently have an unhealed injury?	Yes / No	If yes, please explain:
16	Any other injuries, illnesses, or other health related issues not listed?	Yes / No	If yes, please explain:

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