EXAMINING POSTURAL CONTROL AND ANKLE LAXITY BETWEEN DIFFERENT CLEAT HEIGHTS IN HIGH SCHOOL FOOTBALL PLAYERS

by

Douglas Arthur Pizac

A thesis submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Master of Science in Biomechanics and Movement Science

Spring 2016

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Approved: _____
Thomas W. Kaminski, Ph.D.
Professor in charge of thesis on behalf of the Advisory Committee

Approved: _____
Charles Swanik, Ph.D.
Director of the Biomechanics and Movement Sciences Program

Approved: _____
Kathleen S. Matt, Ph.D.
Dean of the College of Health Sciences

Approved: _____
Ann L. Ardis, Ph.D.
Senior Vice Provost for Graduate and Professional Education

ACKNOWLEDGMENTS

There are many people whom I would like to dedicate this thesis document to. To my family: my parents Betty and Doug as well as my sister Kelsey. Your unwavering support has gotten me through these past two years of graduate studies on the opposite side of the country. I would also like to thank my fellow graduate students, especially Chelsea Best and Shannon Matheny for their roles in my thesis research that made all of this possible. Thanks to Jaclyn Caccese and Andrea Di Trani for welcoming me into the lab and answering any and all questions I had. Thank you to Dan Watson, Dr. Reisman, Kyle Martinelli, Hodgson head coach Frank Moffett and all of the exceptional student-athletes I got to work with. You all made this project seem less like a graduation requirement and more as an enjoyable.

Finally, I must thank the members of my Thesis committee. Thank you to Dr. Joe Glutting for always answering my statistics and SPSS questions, and Dr. Swanik for valuable input on improving my research design. Last but definitely not least, thank you to my committee chair and advisor Dr. Thomas W. Kaminski for taking a chance on me to be one of your graduate students two years ago. You have been more than a mentor to me, thank you for allowing me to confide in you and for sharing so many experiences that I will carry with me following graduation and beyond.

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ABSTRACT

Context: Lateral ankle sprains are the most common injuries in high school sports. While ankle taping is a preferred method of external prophylactic support, its restrictive properties decline during exercise. The Under Armour® Highlight cleat is marketed on the premise that it provides added support without the need for additional ankle taping. **Objective**: To determine if differences in ankle joint laxity and postural control exist between football players wearing the Under Armour® Highlight cleat (Baltimore, MD) as compared to a low/mid-top cleat with ankle tape. **Design**: Crossover trial. **Setting**: Athletic training room and football practice field sideline. **Patients**: Thirty-two interscholastic football players (15.8±1.0 yrs.; 178.9±7.4 cm; 87.1±21.4 kg). **Interventions**: Ankle laxity was assessed using an instrumented ankle arthrometer (Blue Bay Research Inc., Milton, FL), while balance testing was performed on the Tekscan MobileMat™ BESS (South Boston, MA). The two treatments included Under Armour® Highlight cleats and a low/mid-cut cleat with ankle tape applied to the non-dominant ankle only. Measurements were taken before and immediately after practice. **Main Outcome Measures**: The independent variable was treatment (Highlight vs low/mid with ankle tape). Dependent variables included ankle arthrometry measures of anterior displacement (mm), inversion/eversion rotation (deg); and the MobileMat™ BESS error scores. Single-leg foam and tandem foam stances were not performed. A linear mixed-effects model was used for analysis. **Results**: The mid/low-cut cleat with tape condition had significantly higher inversion range-of-motion (ROM) and inversion/eversion rotation post-exercise when compared

to the Highlight cleat ($p<0.05$). **Conclusions**: The results of this study provide some evidence that the Under Armour® Highlight cleat restricts ankle ROM following a training session better than the taped low/mid-cut cleat. Further study is warranted to determine if this high-top style of football cleat can reduce the incidence of ankle sprains and how it might compare to spat taping.

Chapter 1

INTRODUCTION

The ankle is the most commonly injured body site in athletes.[1-4] Specifically, lateral ankle sprains account for a majority of these injuries, and are one of the most common injuries among high school sports participants.[5-10] Hubbard et al. reported that it can even take up to three months before ligament healing occurs[6], while Anandacoomarasamy et al. found that many people still had symptoms of pain, swelling, weakness and/or instability when assessed 1.5-4 years following injury.[5] Recurring ankle sprains with lasting symptoms can result in the ankle becoming mechanically unstable, a condition known as Chronic Ankle Instability, or CAI.[6] Furthermore, millions of dollars are spent each year on treatment and rehabilitation of these injuries.[11]

The concern over the high prevalence rate of ankle sprains along with a high recurrence rate motivates clinicians to examine ways to prevent these injuries. Ankle taping is a popular method used by athletic trainers for providing external prophylactic support to the ankle joint. Taping significantly decreases the amount of inversion range-of-motion (ROM) at the ankle compared to no taping.[12] Ankle taping improves neuromuscular control[13] and holds the ankle joint in a more neutral position;[14] and provides the athlete an increased feeling of confidence and stability.[15,16] However, Sawkins et al. discovered that these feelings of confidence and stability were also present when using a placebo taping during walking or jogging gait, reducing the likelihood of incurring an ankle sprain.[15] Several pitfalls associated with taping

interventions include: (1) high cost per season and (2) restrictive properties are reduced during exercise. Best et al. found that while taping reduced inversion ROM to 50.3% of baseline ROM, 45 minutes after a soccer-specific intervention that restriction had fallen off to just ten percent.[12]

Due to the large costs and limited effectiveness associated with ankle taping, alternative methods of external prophylactic support to the ankle joint have been considered. Ankle bracing is one such intervention that allows for a lower cost and reusable prophylactic intervention.[9,17] Ankle bracing reduces the incidence of ankle injury in basketball[18] and football[19], but not the severity of the resulting sprains as measured by time removed from athletic participation. Bracing provides external prophylactic support without sacrificing performance factors necessary for success in athletics such as speed or jumping ability.[20,21] In fact, a literature review conducted by Verhagen et al. found that while taping and bracing both reduce the incidence of ankle sprains, bracing seems more effective in preventing ankle sprains than taping.[22]

For many years, basketball players have been wearing basketball shoes that extend above the malleoli of the ankle, coined a "high-top" shoe. Recently, this high-top design has grown popular within football, especially by lineman requiring an extensive amount of stability to perform their position effectively. Therefore it seems plausible that such a novel concept in cleat design could also provide a prophylactic benefit and take the place of preventative taping and bracing. High-top cleats, once thought to be worn only by lineman, are becoming increasingly popular among skilled players who wear versions that are sleeker and lightweight in composition. They are almost boot-like in nature because of how far the upper portion of the cleat extends above the medial and lateral malleoli of the ankle. Several studies have examined the

role of shoe design and how it relates to injury.[23,24] While football cleat studies have looked at plantar pressures, type and number of cleat studs used, and compared cleats on artificial turf and natural grass; none have examined the stability and comfort properties reported to exist with these cleats. In basketball, researchers have found that high-top basketball shoes are effective in helping athletes resist inversion moments.[25-27] To our knowledge, no studies have evaluated postural control while wearing football cleats, which is critical for injury prevention as poor postural control is one of the many determinants for risk of ankle sprain.[28]

As the popularity of high-top cleats in football rises, the need to examine their impact on injury prevention and sport performance escalates. Therefore, the purpose of this study was to evaluate postural control and ankle laxity in football players wearing high-top cleats as compared to wearing low or mid-top cleats. Two major aims guided this project, including: (1) To examine the restrictive properties of the high-top cleat without tape versus a low/mid-top cleat with ankle taping before and after exercise; and (2) to examine the postural control properties of the same conditions before and after exercise. For both aims, we hypothesized that the taped treatment would be superior in both postural control and restrictive capabilities prior to exercise; whereas post-exercise the high-top cleat would demonstrate superiority.

Chapter 2

METHODS

2.1 Design

A pre/post-test crossover design was used in this study. There were two testing sessions, one testing a high-top cleat and the other testing a low/mid-top cleat with ankle tape. The Under Armour® (Under Armour Inc., Baltimore, MD) Highlight cleat (Figure 2.1) was used for the high-top treatment. Under Armour® claims this cleat is "super high and ridiculously light" and provides a sort of "second skin" intended "to provide powerful support and an incredible feel, forgetting tape and extra weight." Our research protocol compared this high-top cleat with other football cleats coupled with ankle tape. Treatment order was counterbalanced, with measurements taken before and after football practice. Testing took place three days per week, with 2-3 subjects tested each day. After seven days subjects were tested in the other condition.

2.2 Participants

Thirty-two male student-athletes from the Hodgson Vocational Technical High School interscholastic football team (age: 15.8±1.0 yr., height 178.9 ±7.4 cm, mass 87.1±21.4 kg) were asked to participate in this study. All subjects signed age-appropriate consent forms approved by the institutional review board [UD IRB #727416-1]. All participants were cleared for participation via the standardized

Figure 2.1: The Under Armour® Highlight cleat.

DIAA (Delaware Interscholastic Activities Association) form appropriately filed with the school nurse. Participants were excluded from the study if they had a lower leg injury prior to or during the study period.

2.3 Procedures

All parental consent, child assent and consent forms were distributed at a parents meeting prior to the start of the season. These forms were collected during pre-season training, and testing began once the school year commenced. After all the consent forms were signed and returned, a questionnaire was given to the student-athletes asking standard anthropometrical questions (height, weight, cleat size), along with ankle injury history (Appendix B.2). Testing was conducted before and after football practice (duration: 123.3±10.9 minutes) and took place at a location just adjacent to the practice field. Upon completion of practice, each subject gave a rating of perceived exertion (RPE) using a Borg scale (Figure 2.2).

6	No exertion
7	
8	
9	
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard (heavy)
16	
17	Very hard
18	
19	
20	Maximal exertion

Figure 2.2: Borg Rating of Perceived Exertion (RPE) scale (6-20)

For the high-top cleat condition, subjects were instructed to secure the Under Armour® Highlight cleats to their feet according to the manufacturer's instructions. For the ankle taping condition, the certified athletic trainer at the high school performed a standard ankle taping for all subjects. All ankle taping utilized Johnson & Johnson Coach™ brand athletic tape (Johnson & Johnson, New Brunswick, NJ). Only the ankle of the non-dominant ankle was be taped. To determine this, the examiner asked each subject which foot the subject would use to kick a soccer ball. For whichever leg the subject answered, the opposite leg was assigned as the non-dominant leg.

2.3.1 Laxity Measurements

All laxity measurements were conducted using an instrumented ankle arthrometer (Blue Bay Research Inc., Navarre, FL). These ankle arthrometers have

been shown to produce reliable measurements for ankle joint laxity.[29] While wearing the cleats we tested the non-dominant ankle on all subjects before and after practice. Subjects were instructed to lie supine on a table with the non-dominant ankle resting just off the edge of the table. The ankle was secured using a restraining strap wrapped over the distal end of the lower leg, approximately one centimeter above the malleoli to prevent any undesired lower limb movement. The cleat was then secured to the arthrometer by tightening the heel and dorsal clamps while the cleat was pressed against the arthrometer foot-plate. Flexible plastic wrap was wrapped around the top of the cleat and the arthrometer foot-plate 2-3 times to secure it to the footplate (Figure 2.3).

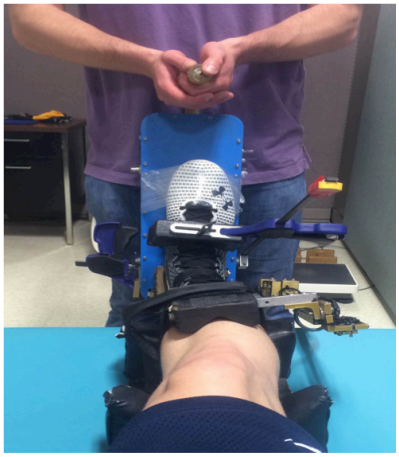

Figure 2.3: Ankle laxity testing using an instrumented ankle arthrometer.

Once secured, the examiner used the arthrometer handle to apply an anterior translation stress using a maximal load of 130 N while the subject's ankle was in zero degrees of plantar flexion. The resulting displacement was measured in millimeters

using LabVIEW software Version 11.0 (National Instruments, Austin, TX). A total of three trials were conducted while the average displacement of those trials was used for data analysis. We then applied an inversion/eversion rotation stress to the subject's ankle, exerting a clockwise torque of 4200 N*mm, returning to the original position, then a counterclockwise torque of 4200 N*mm, and finally returning to the original position. The amount of inversion/eversion ROM was measured in degrees, and a total of three trials were conducted with the resulting value as the average of the three trials. In addition, a specially developed LabVIEW program enabled us to separate the inversion only and eversion only components within the three trials.

2.3.2 Postural Control Measurements

Postural control testing involved a Tekscan MobileMat™ BESS (Tekscan, South Boston, MA). A study by Caccese et al. found that the Tekscan MobileMat™ BESS program is a reliable method in evaluating deficits in postural control compared to human observed errors.[30] The subject was instructed to perform three different stances, under both cleat conditions. The stances included a double-leg stance with the feet shoulder-width apart, a single-leg stance on the non-dominant leg, and a tandem stance with the non-dominant foot behind the dominant foot lining up heel-to-toe (Figure 2.4). During each stance the subject closed their eyes for 20 seconds with their hands placed on their iliac crests. There was a 30 second rest period in between each stance to limit fatigue. Once these three stances were completed on the MobileMat™, the double-leg stance was performed again, only this time with a foam pad in between the subject and the MobileMat™. The BESS protocol typically includes performing the single-leg and tandem stances with a foam pad in between the subject and the MobileMat™, but for our modified protocol we omitted these stances due to extreme

difficulty of performing them in football cleats. The MobileMat™ determines errors by calculating by changes in the subject's center of pressure, and whether or not they out of the tested stance. Our total BESS score was the sum of these four stances.

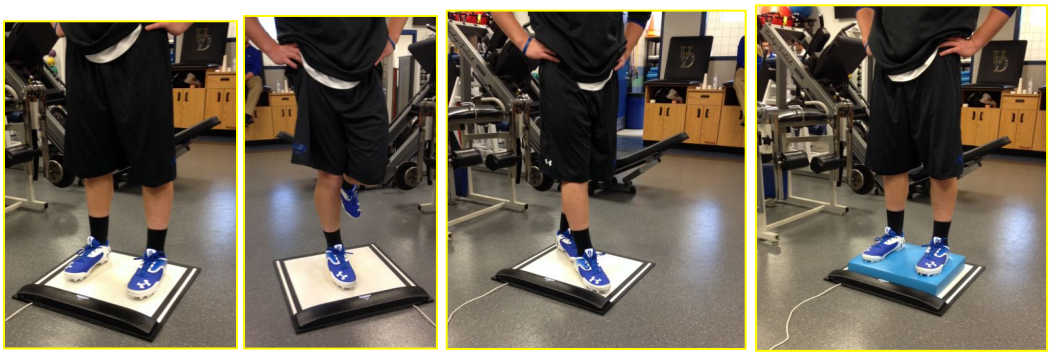

Figure 2.4: Modified Balance Error Scoring System Stances (left to right): double-leg firm, single-leg firm, tandem firm, double-leg foam.

2.4 Statistical Analyses

The independent variable in this study was treatment (Highlight cleat vs. low/mid-cut cleat with ankle tape). The dependent variables included both ankle arthrometry and postural control measurements. Ankle laxity measurements included both anterior displacement (mm) and inversion/eversion rotation (deg). Postural control was evaluated using error scores derived from the computerized Tekscan MobileMat™ BESS. Error scores were calculated from each of the different stances and surfaces. In addition to these individual scores, the sum of all four was also analyzed.

Statistical analyses were conducted using a series of linear mixed-effects models (LMM). These models control for the order in which each treatment occurs better than traditional ANOVA models. All analyses were conducted using SPSS

Statistics Version 23 (SPSS Inc., Chicago, IL) with significance set at a p-value ≤ 0.05. A negative estimate (b) indicated a better score for the Highlight cleat treatment, while a positive estimate indicated a better score for the Taped treatment.

2.4.1 Analytic Methods

Using LMM analyzes with crossover designs better considers the effects of random variables. The fixed effect for each analysis was the type of treatment: Highlight condition versus taped condition. Two random effects were specified: (1) subjects and (2) order. A code of 1 for the order random effect represented the presentation of the taped treatment (T) preceded the Highlight cleat treatment (H). A code of 0 for the order variable represented the H condition preceded by the T condition. Pretest scores for the dependent variable under consideration served as covariates. A number of variance-covariance structures were compared using the AIC and BIC measures of model fit, as well through the use of deviance testing. Convergence was achieved across the four models only when an identity structure was employed.

The advantages of the LMM versus the traditional application of an analysis of covariance (ANCOVA) or a repeated measures analysis of variance (ANOVA) have been reported elsewhere.[31,32] ANCOVA and repeated measures ANOVA are limited by the assumption of compound symmetry. A large number of error structures are available. Researchers using LMM are free to test a number of variance-covariance structures to see which one best fits the data. Thereby, LMM curves serve to reduce the overall error in a study.[33] Equally important, LMM does not require balanced data. Researchers can have unequal numbers of subjects in the E and C treatment groups or in the treatment order.[34,35]

Chapter 3

RESULTS

Thirsty-two subjects completed the study protocol. The mean self-reported Borg RPE was 13.5±3.1. Based on their answers from the subject questionnaire, seventeen had no history of ankle injuries, and fifteen had a history of at least one or more acute ankle sprains (Mean number of sprains: 0.7±0.8). One subject also had a history of ankle fracture. Postural control data were lost on two subjects and excluded from analysis. However, we had useful ankle laxity data on all 32 subjects.

3.1 Ankle Laxity Data

Ankle laxity measurements across both treatments before and after exercise are shown in Table 3.1. It is important to note how close the pre-exercise values were on all three measurements. Significant differences were found in inversion and total inversion/eversion ROM (Table 3.2). Unlike the *taped* treatment where mean inversion ROM increased from 11.6±4.0° before practice and 17.6±7.7°(Δ=6°) after practice, the *Highlight* cleat treatment only increased from 13.8±4.1° before practice to 16.2±4.0° (Δ=2.4°) after practice. This same trend occurred for total inversion/eversion ROM, whereas the taped treatment increased from 17.6±6.3° to 27.5±12.6° (Δ=9.9°) whereas the *Highlight* cleat treatment only increased from 21.2±6.5° to 25.0±5.9° (Δ=3.8°). Eversion ROM was not analyzed as it did not meet the criterion required to run the LMM. Additionally, there were no significant differences between treatments for anterior displacement ($p = 0.116$).

An additional analysis looked specifically at twelve of the thirty-two subjects that were identified as "skilled" players; these position football players included running-backs and wide-receivers. Due to constraints from the LMM, only inversion ROM was analyzed. There was a significant difference in inversion ROM (b = -5.580, df = 17.876, p = 0.013) whereas the *Highlight* cleat treatment scored higher (16.0±4.5 to 17.5±4.7°, Δ=1.5°) than the *taped* treatment (11.4±4.3 to 18.8±7.4°, Δ=7.4°).

Table 3.1: Ankle Laxity (mean ± SD) for both Treatments Before and After Exercise

	Pre-Practice				**Post-Practice**			
	Ant. Dis (mm)	**Ev. ROM (deg)**	**Inv ROM (deg)**	**Inv/Ev (deg)**	**Ant. Dis (mm)**	**Ev ROM (deg)**	**Inv ROM (deg)**	**Inv/Ev (deg)**
Highlight	6.4±2.0	7.4±3.0	13.8±4.1	21.2±6.5	7.9±1.9	8.9±2.9	16.2±4.0	25.0±5.9
Taped	6.5±2.0	6.0±3.2	11.6±4.0	17.6±6.3	8.5±2.6	10.0±5.9	17.6±7.7	27.5±12.6

Table 3.2: Results from Three Linear Effects Models for Treatment for Ankle Laxity

Measurement	**Estimate (b)**	**Degrees of Freedom (df)**	**t-value**	**Sig.**	**95% CI Lower Bound**	**95% CI Upper Bound**
Anterior Displacement	-0.627	31.936	-1.416	0.166	-1.529	6.327
Inversion ROM	-3.197	35.771	-2.699	0.011	-5.600	-0.794
Inversion/Eversion ROM	-5.890	35.509	-3.102	0.004	-9.742	-2.037

Note: Treatment 1 = Highlight, 0 = Taped
Random Effects = Subjects and Order

3.2 Postural Control Data

Keeping in mind that the two most difficult stances of the BESS test were not performed with our subjects wearing cleats, the BESS error scores across both conditions pre- and post-exercise are highlighted in Table 3.3. After controlling for

order of treatment and the pre-practice measurements, no significant differences were found in the single-leg firm, double-leg foam or sum of the four stances of the BESS scores (Table 3.4). The double-leg firm stance and the tandem firm stance were not analyzed, as they did not meet the criterion required to run the LMM.

Table 3.3: BESS Error Score (mean ± SD) for both Treatments Before and After Exercise

	Pre-Practice					Post-Practice				
	Dbl-leg firm	**Single-leg firm**	**Tandem Firm**	**Dbl-leg foam**	**Total BESS Score**	**Dbl-leg firm**	**Single-leg firm**	**Tandem Firm**	**Dbl-leg foam**	**Total BESS Score**
Highlight	0±0	6.0±3.0	2.4±1.9	1.3± 1.4	9.7± 3.9	0±0	5.6±2.8	1.7±1.8	1.3± 1.3	8.6± 3.3
Taped	0.1± 0.5	5.7±3.0	1.9±1.9	1.0± 1.0	8.7± 3.5	0±0	5.7±2.6	2.2±2.1	1.2± 1.4	9.1± 4.1

Table 3.4: Results from Three Linear Effects Models for Treatment for the Balance Error Scoring System Stances

Stance	**Estimate (b)**	**Degrees of Freedom (df)**	**t-value**	**Sig.**	**95% CI Lower Bound**	**95% CI Upper Bound**
Single-Leg firm	-0.076	26.733	-0.117	0.908	=1.414	1.262
Double-Leg Foam	0.019	27.620	0.059	0.954	-0.653	0.691
Modified BESS Sum	-0.671	29.044	-0.746	0.462	-2.513	1.170

Note: Treatment 1 = Highlight, 0 = Taped
Random Effects = Subjects and Order

Chapter 4

DISCUSSION

Football cleat technology has advanced over the last ten years to include high-top cleat designs made from lighter weight yet supportive materials. One such product currently available includes the Under Armour® Highlight cleat, touted to provide increased stability without decrements in performance. Additionally, the extended upper portion of the cleat may mimic the benefits afforded from prophylactic taping and bracing. The purpose of this study was to evaluate postural control and ankle laxity between a high-top football cleat and a low/mid-top football cleat. We hypothesized that the taped treatment would emerge as the superior method for both dependent variables prior to exercise. However, the loss of the tape's restrictive properties during football practice would make the Highlight cleat treatment the superior choice post-exercise.

4.1 Ankle Laxity

Interestingly, prior to practice, the laxity values taken from both treatments were quite similar. However, after practice the stability provided by the Highlight cleat treatment was significantly better (less decrement in ROM restriction) as compared to the Taped treatment. This was true for both inversion and total inversion/eversion ROM. Equally important is that the small change in inversion restriction (Δ=2.4°) of the Highlight cleat is in the direction that most ankle sprains occur. This finding lends further support to the argument that over time the stability

provided by ankle taping is decreased as activities persist. While this finding is an important first step, further research is needed to determine whether or not those wearing the Highlight cleat will experience less ankle sprains than those in taped conditions.

To our knowledge, this is the first research effort examining laxity in athletes wearing football cleats, especially those wearing high-top cleats. While high-top basketball shoes have been around for several decades, none have directly examined laxity measurements with arthrometers similar to ours. Therefore, we have tried to compare and contrast our results with pertinent literature that involved ankle taping and bracing.

Two such studies, with which we compare and contrast involved the use of electro-goniometry to measure the effects of taping prior to and immediate following activity.[12,36] However, neither assessed their subjects while wearing the respective footwear. Using a 45-minute soccer-specific intervention, Best et al. reported an increase in inversion laxity for their taped group of 5.6° from pre- to post-exercise.[12] Compared to Best et al., their finding is very similar to ours in that we saw an increase in inversion ROM of 6.0° degrees from pre- to post-exercise. It is important to note that our testing was conducted with the cleat in place. We argue that the stability provided by ankle taping lessens as the time and intensity of activity increases. A separate study conducted by Purcell et al. examined differences in ankle ROM between white cloth tape, self-adherent tape and no tape before and after a thirty-minute exercise intervention.[36] While Purcell et al. did not measure inversion ROM independently, they did report an increase in combined inversion/eversion ROM from pre- to post-exercise of 4° within their taped condition.[36] We report an even higher

pre- to post-exercise difference in total inversion/eversion ROM of nearly 10°. This difference could potentially be explained by the length of the respective exercise interventions, as the mean exercise duration in our study was almost four times longer than the exercise protocol used by Purcell et al. Therefore, increased exercise time in our study could give more time for the tape to stretch out and continue to lose its restrictive properties. This begs the question as to whether or not the ankle is more susceptible to undesirable inversion moments that may increase the risk of sustaining an ankle sprain. Interestingly the slight change in total inversion/eversion ROM of only 3.8° in the Highlight cleat despite 120 minutes of a vigorous football practice holds promise for an alternative prophylactic benefit against potentially injurious inversion moments.

4.2 Postural Control

Contrary to our hypothesis, our results indicated no significant differences between the Highlight cleat treatment and the taped treatment with regard to BESS scores. Both treatments exhibited a similar number of errors in BESS scoring prior to exercise, which remained unchanged post-exercise. These findings point to the fact that neither treatment had a detrimental effect on our measure of postural control. The computerized BESS testing technology utilized in our study is new and therefore there are no studies with which to compare BESS error scores directly. Similarly, our exclusion of the single-leg foam and tandem foam stances because of the difficulty of performing them while wearing cleats makes it difficult to compare with others who report total BESS error scores. It is important to understand that the cleat to Tekscan mat interface is different than the barefoot to Tekscan mat interface; inherently, more errors are expected. Moreover, football cleats are intended to interact with grass or turf

fields, while the Tekscan mat interface is composed of a hard tile surface, not necessary intended to be in contact with football.

One particular study has used the BESS to compare preventative taping and bracing with similar results.[37] A 2009 study by Broglio and colleagues that compared three groups of subjects before and a 20-minute treadmill walk offers a nice comparison to our results. The three groups included a barefoot group, an ankle taping group, and a lace-up ankle brace group. No significant differences were found between the taping and bracing group for any particular stance or for the total BESS score.[37] However, in stark contrast contrast to our results, both of their braced and taping groups saw significant improvements in BESS scores from baseline to post-exercise.[37] In addition, Broglio et al. also reported lower mean error scores for the single-leg firm (3.5 pre-exercise; 2.8 post-exercise), tandem firm (0.79 pre-exercise; 1.37 post-exercise) and double-leg foam (no errors made) stances[37] as compared to our study (Table 3.3). As previously stated, football cleats are not intended to be worn on hard surfaces; this could provide an explanation as to why our error scores were higher than those of other studies; but more consistent pre to post-exercise in our study. The most peculiar finding they reported was that the barefoot condition resulted in lower error scores and better postural control performance than either the taping or bracing groups.[37] This would suggest that external prophylactic support may actually have a negative impact on postural control. One consideration as to why this occurs may be associated with the restriction in ankle mobility while wearing tape or ankle braces.[37] Limited movement within a prophylactic support may only allow athletes limited compensation to correct finite shifts in the center-of-mass while performing a balance task. In regards to the single-leg stance, the limited movement within the tape or cleat

may force the athlete to touch the contralateral limb to the ground in order to maintain postural control. If postural control is indeed limited by the ROM restriction involved with an external prophylactic support, then athletic trainers and clinicians may need to take into consideration if this trade-off is beneficial to the overall goal of limiting an athlete's risk of sustaining an ankle sprain.

While decrements in the restrictive properties of ankle taping have been seen through increased ROM following exercise, a 2009 study came to a similar conclusion when measuring postural control.[38] After replicating energy expenditure similar to a soccer match by using a 45-minute treadmill intervention, Lohkamp et al. reported that their taped group had better reaction times to a random perturbation than the no tape group during the first 15 minutes.[38] However, any postural control benefits associated with ankle taping were negated the remaining 30 minutes[38], insinuating that the loss of the tape's restrictive properties was responsible for the increased latency in reaction time. However, it should also be considered that the decline in performance seen may have been attributed to fatigue. The soccer-specific intervention employed by Lohkamp et al. had subjects run at varying treadmill speeds changing every six seconds[38]; while Broglio et al. had subjects walking at a constant speed of 3.0 mph.[37] The large range in intensity as well as exercise duration employed by the two studies could potentially explain why their findings were in disagreement. Further research is needed to determine if exercise intensity and duration influence how an athlete maintains postural control while wearing ankle taping or bracing.

Previous literature shows a practice effect can be elicited when repeatedly administering the BESS.[39] These effects were seen in the total BESS scores during the third and fourth administrations of the BESS test, which took place five days and

seven days following the initial administration.[39] In an attempt to minimize practice effects, we counterbalanced the order in which treatments were administered to prevent any favorable advantage for either treatment should postural control adaptations have been made following the first administration of our modified BESS test. In addition, the LMM analysis controlled for the order in which treatments occurred for each subject. Upon analysis, order was found insignificant for each stance and the total BESS score, and therefore should not be considered as interfering with the findings of this study.

While the BESS is a measurement of static postural control, other studies have failed to determine benefits associated with ankle taping using alternative measures. Although subjects reported increased subjective feelings of confidence and stability associated with ankle taping[15,16], measurements of dynamic stability such as the Star-Excursion Balance Test (SEBT)[15,16] and Dynamic Postural Stability Index[40] found no significant improvements due to the application of ankle taping. Overall, the literature appears to be divided on if an external prophylactic support to the ankle can evoke improvements in postural control. Since no preventive modality definitively allows athletes greater postural control performance, other factors important in minimizing the risk of sustaining an ankle sprain should be taken into account when selecting a means to provide protective support to the ankle. Therefore, the Under Armour® Highlight cleat's ability to limit inversion ROM better than a low/mid-cut cleat has potential as an appealing alternative to more conventional modalities.

4.3 Exercise Intensity

In an attempt to understand exercise intensity and effort within the controlled football practice environment under which our participants were involved with, we

utilized the 15-point Borg RPE scale. Our mean Borg RPE was 13.5±3.1, which equates to somewhat hard to heavy exercise intensity and indicates the higher level of exertion associated with these practices. For comparison, the Purcell et al. study from 2009 had employed a similar Borg scale.[36] They reported that their exercise intensity of 30 minutes in duration ranged between moderate to strong (heavy).[36] We feel strongly that research using exercise intervention protocols should report levels of exercise intensity on a consistent basis so that comparisons across studies can be made.

4.4 Limitations

We acknowledge the presence of a few limitations in this study. First of all, we chose not to include a barefoot treatment as a "control" to evaluate postural control and ankle laxity prior to the application of our prophylactic treatments. Utilizing a barefoot treatment would provide insight on how both the Highlight cleat and the low/mid-cut cleat with ankle tape contribute to ROM restriction and postural control performance. Even so, a barefoot treatment would not have contributed to the overall purpose of our study as we wished to directly compare the Highlight cleat to a low/mid-cut cleat with ankle tape.

Second, only the non-dominant ankle was assessed for ankle laxity. One previous study indicated that patients with self-reported unilateral Functional Ankle Instability (FAI) demonstrated greater anterior displacement in the unstable ankle when compared to the uninjured ankle.[29] However, these findings did not hold true for inversion and total inversion/eversion ROM.[29] Should the non-dominant ankle of any of our subjects be considered functionally unstable, this would not impact any of our significant findings.

Finally, for both the Highlight cleat and taped treatments we were unable to provide each subject with a brand new pair of football cleats for each session. Some subjects may have had to share a pair, all of which were only worn during their respective testing session and returned to the examiner immediately following post-exercise measurements. We acknowledge that earlier subjects in this study may have broken in a pair of cleats for later subjects.

Chapter 5

CONCLUSIONS

Our results suggest that the Under Armour® Highlight cleat may be a favorable option over additional ankle taping to provide external prophylactic support to the ankle joint. Significant increases in inversion and total inversion/eversion ROM were seen with the taped treatment while the Highlight cleat better maintained its restrictive properties. Future research is warranted to see if this style of high-top cleat can reduce the incidence of ankle sprains and how it may compare to other preventative modalities such as spat taping.

Disclaimer: This project was externally funded by Under Armour®.

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Appendix A

LITERATURE REVIEW

A.1 Epidemiology, Assessment and Treatment of Lateral Ankle Sprains

The ankle is the most commonly injured body site in sports, accounting for between 10-30 percent of all sports injuries.[1] with ankle sprains accounted for 76.7 percent of these ankle injuries.[1] These findings are similar for participants in high school athletics.[2] Kaminski et al. stated that approximately 45% of all athletic injuries are due to ankle sprains.[3] Most of these ankle injuries are due to sprains of the lateral ankle ligaments. The most commonly sprained ligament is the anterior talofibular ligament (ATFL) followed by the calcaneofibular ligament (CFL) and posterior talofibular ligament (PTFL). [3] These sprains occur when a stress is applied to an inverted and plantar flexed foot. [3] Injury mechanisms are most frequently due to contact with another person, followed by contact with the playing surface.[2,4]

Ankle injuries are more frequent in competition rather than in practice, with the exception of women's volleyball.[4] This may be due to the controlled environment of the practice setting where maximal intensity is not required. When separating gender, females have a similar ankle injury rate as males.[2,4] Males see more ankle injuries during practice than females, but females experience a greater number of ankle injuries than males in competition.[4] Football accounts for the greatest number of all high school ankle injuries. [4] However, boys' basketball has the highest rate per exposure of high school ankle sprains.[2]

There are multiple risk factors that increase the probability of sustaining a lateral ankle sprain. Athletes with inflexible ankles, as measured by dorsiflexion range-of-motion, are up to five times more likely to incur ankle sprains than athletes with an average amount of ankle flexibility.[5] Ankle strength is also a predictive factor, as higher eversion/inversion strength ratios were found in an injured group.[5] Low and high arches of the foot can be risk factors of lateral ankle sprains, as excessively pronated or supinated feet have been associated with neuromuscular control deficits compared to neutral foot structures.[6] In a study conducted by Denyer et al., peroneus longus reaction times were slower in pronated and supinated feet than in neutral feet. As the peroneus longus plays a direct role in the dynamic defense mechanism, increased latency may render these muscles incapable of protecting the ankle joint during sudden inversion.[6] Tregouet et al. found that common muscle response times of the peroneus longus were between 56-66 milliseconds.[7] During testing on a simulated inversion platform, subjects with no history of ankle injuries experienced peak inversion in as quickly as 22 milliseconds. [7] Since the peak inversion took place faster than the muscle could react to sudden unexpected inversion, the rate of inversion may need to be considered another key factor towards risk of ankle injury. [7]

When evaluating an athlete following an acute injury, the physician should first ask about the athlete's previous history of injury. [3] History of ankle sprains is the most common predisposition for reoccurring ankle sprains. [2,3] The most common mechanism of ankle sprain occurs when the athlete reports of "rolling" their ankle.[8] Pain and swelling is mainly found on the lateral side of the ankle over the anterior talofibular ligament.[8] When observing the injured ankle, clinicians look for swelling,

ecchymosis and deformity.[3] Point tenderness over the injured ligaments can be found upon palpation.[3]

Due to pain and rapid swelling, clinical stability tests to evaluate the lateral ankle ligaments are best performed four to seven days post-injury. [8] To assess the integrity of the ATFL, the anterior drawer test is performed. Subjects lie supine on a table with the knee flexed while the examiner grasps the heel in one hand and pulls forward while stabilizing the distal tibia with the other hand. If there is increased anterior translation of the talus with respect to the tibia, especially when compared to the contralateral limb, then a tear in the ATFL is suspected. [9] The anterior drawer test has a sensitivity between 32 and 80 percent, with a specificity of 80 percent.[3] To assess the calcaneofibular ligament, the talar tilt test is used. With the ankle in neutral dorsiflexion, the calcaneous and talus are moved into inversion while the distal tibia is stabilized. [8] As with the anterior drawer test, significant differences in range-of-motion compared to the contralateral limb is an indicator of ligamentous sprain. The talar tilt test has a reported sensitivity of 52 percent. [3]

The severity of which a ligament is sprained is based on a grading scale from I to III. A grade I (mild) ligament sprain is considered a microscopic injury without damage at the macroscopic level. There is little to no swelling or tenderness, almost no loss in function, and no mechanical joint instability. [8] Grade II (moderate) involves macroscopic stretching with the ligament remaining intact, moderate pain, swelling and tenderness over the lateral structures, and some loss of range-of-motion as well as mild instability. Grade III is a complete rupture of the ligament with marked swelling, hemorrhage and tenderness. [8] Function is lost while range-of-motion and instability is abnormal. [8]

Treatment following ankle sprain should involve rest, ice, compression and elevation. Ice should be used responsibly to minimize pain and swelling while decreasing secondary injury. [3] Compression and elevating the injured limb above the heart level will also minimize swelling. [3] To rehabilitate the ankle following sprain, the main goals are to decrease pain and swelling while protecting the joint from secondary inflammation.[10] Athletic trainers, physical therapists, and physicians want to return the athlete to play as quickly as possible without subjecting the injured tissue to further trauma. [10] Following lateral ankle sprain, the focus should be on returning strength, range-of-motion, and neuromuscular control back to pre-injury levels.[11] Exercises should be done only as much as the athlete is able to tolerate.[11] Range-of-motion exercises should involve both active and passive movements and include plantar flexion and dorsiflexion.[11] Once weight bearing on the injured side is achievable, balance and neuromuscular control exercises should be implemented in the rehabilitation program. Balance training programs have been proven to significantly reduce risk of ankle sprains when compared to standard conditioning programs.[12] To be cleared to fully return-to-play, the athlete should have full ankle range-of-motion and have regained 80-90 percent of strength prior to injury.[11] The athlete should also exhibit a normal gait pattern and be able to perform sport-specific tasks such as running or cutting without any compensating.[11] Tests evaluating static and dynamic postural control such as the Star Excursion Balance Test are useful in evaluating whether or not an athlete is fit to return-to-play. [3]

Ankle sprains continue to plague athletes by prolonging their return to sport. Besides having an estimated annual health care cost of two billion dollars.[6] Swenson et al. found that those who suffer from ankle sprains were either out for 1-6 days

(49%) or 1-3 weeks (40%).[2] Nelson et al. had similar findings, but 10.5% of those reported ankle injuries resulted in athletes missing activity for 22 days or longer.[4] Athletes suffering from lateral ankle sprains may endure lasting issues long after the acute trauma. In a retrospective case-control evaluation, Anandacoomarasamy et al. found that 74 percent of subjects had at least one persistent symptom 1.5-4 years following ankle sprain.[13] Healing of the injured ligaments takes at least between six weeks and three months, but mechanical laxity and ankle instability may persist even a year following injury.[14] Even after healing, deficits in static and dynamic postural control existed in subjects with a history of ankle sprain when compared to healthy controls when in a fatigued state.[15] This means that injury deficits caused by ankle sprain persist long after the athlete returns-to-sport, making the athlete vulnerable to future injury.

There is even a medical condition for ankles that consistently "give way" or a subject to repetitive injury. Experiencing multiple ankle sprains with persistent symptoms is a condition termed as Chronic Ankle Instability or CAI.[14] Not only does it limit physical activity, CAI can lead to articular degeneration of the ankle and increase one's risk of developing osteoarthritis.[14] A complete tear (Grade III) of the ATFL or CFL may also result in chronic instability, even following surgical reconstruction.[9] Other associated injuries with CAI include anterolateral impingement lesions and ankle synovitis.[9]

As previously stated above, football players experience the greatest number of ankle sprains in a high school population.[4] This is most likely due to the large number of participants in football programs and that most high schools have a football program. These injuries occurred most often by tackling, followed by blocking and

being stepped on.[4] A majority of football ankle sprains occur during running plays, then passing plays and finally special teams plays.[4] Most of these ankle sprains were sustained by running backs (26.4%) and wide receivers (11.6%).[4] Of these football ankle sprains, 81.8 percent were sprains for the first time, and 10.6 percent of them occurred while the athlete was wearing an ankle brace.[4]

A.2 Instrumentation

When a sprain is suspected, athletic trainers and clinicians use the anterior drawer, talar tilt and inversion/eversion stress tests to assess the talocrural and subtalar joints of the ankle.[9] An instrumented ankle arthrometer is considered a suitable tool to evaluate ankle ligament laxity.[9] It is a six-degrees of freedom spatial kinematic linkage system, measuring three translations and three rotations of the ankle joint.[9] Arthrometer measurements quantify the anteroposterior load displacement as a result of the anterior drawer test, and the inversion/eversion rotational laxity characteristics of the ankle joint.[16] High intratester and intertester reliabilities have been found using the instrumented ankle arthrometer (ICC = 0.80 to 0.97).[9] An ankle can be considered pathological if there is an anterior translation of ten millimeters or more, or if the difference between the two ankles is greater than three millimeters.[16] For the talar tilt test, the ankle is pathological if inversion is greater than or equal to nine degrees or there is three degrees of difference between both ankles.[16] However, these protocols loaded the ankle with 125 Newtons of anterior and posterior force to measure AP displacement, and 4 newton-meters of inversion/eversion torque to measure rotation. For our protocol, we will use an anterior translation force of 130 Newtons with no posterior force applied, and 4.2 newton-meters of inversion/eversion torque.

Therefore, our values may appear pathological due to increased force and torque applied to the ankle joint.

Most athlete endeavors will require some amount of static and dynamic postural control. Postural control evaluations are continuously performed during an athletic injury assessment. A person's ability to maintain postural control is based off of four main components: afferent information from the eyes, vestibular and somato-sensory systems, interpretation of these systems into a motor command, and effect information that induces a movement response.[17] Following ankle injury, postural control may be negatively affected if the mechanoreceptors are damaged within the ligaments and joint capsule.[17] Postural sway evaluated by center of pressure displacement is one of many predictors of ankle sprains.[5] Deficits in postural control are found on both the injured and uninjured sides following acute lateral ankle sprain.[18] Hopper et al. concluded the single-leg stance test is valid and reliable in predicting ankle injury as quantified by postural sway on a force plate.[19] One program that reliably measures postural sway is the MobileMat™ Balance Error Scoring System (BESS) program. Originally used to evaluate athletes suspected of a concussion, the BESS test is also capable of detecting postural control deficits following lower extremity injury.[17] The associated computer program assesses postural control by measuring changes in center of pressure while performing a selected stance. Caccese et al. found that these computer-generated BESS scores are as reliable in measuring postural control deficits as errors manually observed by clinicians.[20]

However, there are limitations that must be taken into consideration when using the BESS test to evaluate postural control. Performing the BESS test

immediately following fatiguing exercise has a negative impact on BESS scores. Thirty seconds of fatiguing exercise is sufficient can be enough to worsen control of postural sway.[19] Wilkins et al. found that subjects undergoing a fatigue protocol greater than 60% of their VO_2 max had significantly more BESS errors compared to their pre-test BESS scores and the control group BESS scores.[21] This fatiguing exercise also affected performance on the tandem stance conditions more than on any other stance.[21] Some authors suggest that a minimum of twenty minutes of rest is required to reduce error scores back to baseline levels, to eliminate fatigue as a confounding variable. [21]

Practice effects or improvements in performance following exposure to the BESS test have been found.[21,22] In a study involving repetitive BESS testing by Valovich et al., there was a significant reduction in balance errors on the foam surface stances and on the firm single-leg stance seven days following baseline testing. [22] However, no significant differences were found with the double-leg and tandem stance conditions. [22]

A.3 Ankle Taping

By now, we know that lateral ankle sprains are a debilitating condition with long-term consequences. To reduce the likelihood of sustaining an ankle sprain, first-time or recurring, providing some type of external prophylactic support to the ankle joint may be useful. One method that is preferred by athletic trainers and clinicians is the use of white cloth tape to wrap the ankle joint in a secure and protective covering. It is multi-purposeful in that taping can be used not just on the ankle, but also on many other different joints. Also, its application contours to each individual, providing a

custom fit to every athlete. Besides white cloth tape, there are other tapes of various elasticity and materials for use depending upon what the desired goal of the taping is.

Taping has many positive effects on an athlete's kinematics. It decreases ankle inversion and holds the ankle in a neutral position during gait.[23] Open chain range-of-motion and ankle laxity are also decreased with taping, providing additional stability to the ankle joint.[23] Taping not only provides mechanical stability, it has neuromuscular benefits including cutaneous proprioceptive input. When the tape is applied to the skin it increases motor neuron pool excitability.[23] This results in an increased joint position sense, improved postural control, and increased lower leg muscular activity.[23]

As previously stated above, the lateral ligaments of the ankle are usually sprained when a stress is applied while the foot is in an inverted and plantar flexed position. Activation of the peroneous longus counteracts sudden inversion. However, if the rate at which inversion occurs is faster than the amount of time before the peroneous longus activates, then the ankle is susceptible to sprain. Taping assists the peroneous longus in managing ankle inversion. A study conducted by Tregouet et al. looked at muscle activation and ankle range-of-motion between controls. Subjects taped with non-elastic taped and subjects taped with an elastic adhesive bandage before and after a thirty-minute treadmill running protocol. While peroneous longus latency was not significantly different across the three groups, taping significantly reduced total inversion, time to peak inversion and the rate of inversion compared to the control group.[7] Between tape types, the non-elastic tape resulted in significantly lower rates of inversion than the elastic adhesive bandage. As stated earlier, peroneous longus latency times range between 56-66 milliseconds.[7] While the unprotected ankle

experienced peak inversion in as quickly as 22 milliseconds with a mean response time of 112 milliseconds, ankles taped by non-elastic tape had an average peak inversion time of 153 milliseconds.[7] This additional time to peak inversion and decreased peak inversion from taping not only provides mechanical stability, its mechanical delay may also be enough to allow the evertor muscles of the ankle to resist sudden inversion. [7]

Ankle taping also has psychological advantages when used by athletes. In a review conducted by Simon and Donohue, no significant differences were found between taping conditions on performance of the Star Excursion Balance Test, a popular clinical evaluation tool for ankle stability. However, the application of ankle tape positively influences an athlete's perception of stability[24,25], confidence and reassurance.[25] Even if no statistically significant change in stability is apparent, having the ankle taped can still be beneficial to an athlete.

While stability is an important factor, many wonder if the use of ankle tape has any negative effects on performance attributes necessary for athletic success. Cordova et al. and Metcalfe et al. found that taping is significantly detrimental to vertical jump[26,27] and agility as measured by the Southeastern Missouri (SEMO) agility test.[27] On the contrary, Cordova et al. found many studies where taping had no negative effects on sprinting performance.[26]

One of the biggest concerns with ankle taping is a rapid loss of its restrictive properties during physical activity. While tape gives an increased sense of stability, confidence and reassurance, athletes experience similar feelings when using placebo tape.[28] Therefore, the increased support that comes from having the ankle taped is predominantly psychological. Studies have found taping ceases to effectively support

the ankle in as little as ten minutes.[26] Tregouet et al. found that the rate of inversion in the non-elastic tape condition significantly increased post-exercise, most likely due to the stretching of the tape.[7] Other studies using a 30-minute exercise protocol found that white cloth tape, the traditional tape used by athletic trainers on the sidelines failed to restrict ankle range-of-motion compared to measurements pre-exercise.[29,30] Best et al. found that taping restricts passive ankle range-of-motion to 50.3 percent in an uninjured ankle.[31] However, following a 45-minute soccer specific intervention this range-of-motion restriction fell to an almost irrelevant 9.7 percent.[31] As a side note, one study even revealed that the temperature in the foot increased by six degrees Celsius post-exercise, especially under the tape.[29] While an increased temperature may increase muscle blood flow to the region,[29] sweat production can cause the tape to slide along the surface of the skin. This may further reduce the effectiveness of ankle taping during exercise. Therefore, alternative external prophylactic means of support should be considered that restrict ankle range-of-motion throughout athletic activities.

A.4 Ankle Bracing

For athletes competing in activities without the assistance of a certified athletic trainer or clinician on the field, taping may not be the most reasonable option. Nevertheless, there are other methods of external prophylactic support that can decrease an athlete's risk of ankle injury. Ankle braces are a commercial-wide option sold in many sporting goods stores. They are available in many styles depending on how much stability is needed, and are sized to fit underneath any athletic shoe.

Unlike taping, ankle braces can continuously be reused following each exercise session, eliminating the need to constantly repurchase rolls of tape. In fact, ankle taping can be 3.05 times more expensive than purchasing reusable ankle braces over

the course of a competitive season.[32] For example, a team of 26 athletes would cost approximately $2778 dollars to tape in a single season, using ankle braces would only cost 910 dollars.[32] A high school football team could save an estimated $1000 per season if ankle taping is replaced by prophylactic bracing.[33] It should also be known that the cost of taping one college football athlete in the course of one season comes to be approximately 400 dollars.[33]

While bracing is the more cost-effective method, effective mechanical support and elite performance are still of great importance. Lace-up ankle braces may reduce the incidence of acute ankle injuries in high school basketball[34] and football players[35] with and without a history of ankle injury. It should be noted that in both these cases that bracing did not reduce the severity of these ankle sprains.[34,35] On the other hand, Verhagen et al. found that taping and bracing were in fact able to reduce the severity of ankle sprains.[36] Both taping and bracing reduced the incidence of ankle sprains, but ankle braces seemed to be more effective in doing so than taping.[36]

Ankle kinematics do not differ when using either tape or ankle braces.[37] Like ankle taping, bracing has a negative effect on vertical jump performance.[26,38] No significant differences were found in speed, balance and agility by using ankle braces.[26,38] In regards to restricting range-of-motion, Cordova et al. also found that ankle braces ineffectively supported the ankle within ten minutes.[26] Following twenty minutes of exercise, inversion and eversion rotation significantly increases in subjects using ankle braces.[39] Even though bracing appears to be more cost-effective and practical than ankle taping, ankle braces experiences similar issues in maintaining protection of the ankle joint during exercise.

A.5 Athletic Footwear

Much research has gone into using ankle taping and bracing as well as other means of external prophylactic support to the ankle joint. Bracing and taping both reduce the incidence of ankle sprains, but they also have limitations. Specifically, their ability to effectively to support the ankle during an entire exercise bout is insufficient. A possible solution is for football players should turn to their choice of footwear as a source of external prophylactic support. If the cleats themselves were able to provide the same support as taping or bracing, it could cut down on athletic training costs even further. However, little research has looked at the role of shoe design in reducing the incidence of ankle sprains, especially when it comes to football.

The way a shoe is designed has an influence on how people move and risk of injury, as an unstable shoe can increase ground reaction forces, ankle inversion and eversion moments, dorsiflexion moments and plantar flexion range-of-motion.[40] Basketball was one of the first sports where the design of the shoe was manipulated to protect the wearer. One idea was to add a cushioned column to the shoe, but Curtis et al. found this did not reduce the incidence of ankle sprains in comparison to basketball shoes without a cushioned column.[41] Another design raised the top of the shoe higher up on the ankle, more commonly known as a three-quarter top or a high-top basketball shoe. With the three-quarter top basketball shoes, subjects significantly increased their resistance to a maximal inversion moment compared to a low-cut basketball shoe.[42-44] Still, it is unclear whether how new the footwear is plays a larger role than shoe height when it comes to preventing ankle sprains.

When it comes to football cleats, most research examines the number of studs and stud patterns on the cleats, none of which have been statistically correlated to risk of lower extremity injury.[45] Studies regarding football have also looked at the

difference between artificial turf and natural grass on risk of lower extremity injuries, with artificial turf increasing risk of injury by 3.34 times during games.[45] The limited number of studies examining cleat height are split in their findings. Johnson et al. was one of the first studies to examine cleat height, finding the high-cut boot was stiffer and considerably reduced the ligamentous load of the ankle compared to the popular low-cut cleat at the time.[46] Iacovelli et al. found that cleat height was not associated with risk of lower extremity injury, concluding that further research into different cleat types must be conducted in order to reduce injuries in football.[45]

A.6 Conclusions

The ankle is the most commonly injured body site in athletic activities, with lateral ankle sprains comprising a majority of these injuries. Taping and bracing are popular means of providing external prophylactic support to the ankle joint, but they lose much of their restrictive properties during exercise. High-top basketball shoes have been found to effectively increase an athlete's ability to resist inversion moments, but little research has investigated whether or not high-top football cleats can protect the ankle joint as effectively as taping or ankle braces. Since postural control deficits and high ankle laxity are known predictors of risk of ankle sprain, utilizing these measures as our dependent variables will provide a valid means to assess a high-top cleat's ability to provide sufficient external prophylactic support to the ankle joint. If this study is successful, eventually we will be able to question if high-top football cleats can reduce the incidence of ankle sprains in high school football players, as well as the remainder of the population who participates in the game of football.

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Appendix B

IRB APPROVED DOCUMENTS

B.1 IRB Approval Letter

UNIVERSITY OF DELAWARE

RESEARCH OFFICE

210 Hullihen Hall
University of Delaware
Newark, Delaware 19716-1551
Ph: 302/831-2136
Fax: 302/831-2828

DATE:	April 3, 2015
TO:	Douglas Pizac
FROM:	University of Delaware IRB
STUDY TITLE:	[727416-1] Examining Balance and Ankle Stability while Wearing the Under Armour® Highlight Cleat in High School Football Players.
SUBMISSION TYPE:	New Project
ACTION:	APPROVED
APPROVAL DATE:	April 3, 2015
EXPIRATION DATE:	April 2, 2016
REVIEW TYPE:	Expedited Review
REVIEW CATEGORY:	Expedited review category # *(4)*

Thank you for your submission of New Project materials for this research study. The University of Delaware IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the study and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All SERIOUS and UNEXPECTED adverse events must be reported to this office. Please use the appropriate adverse event forms for this procedure. All sponsor reporting requirements should also be followed.

Please report all NON-COMPLIANCE issues or COMPLAINTS regarding this study to this office.

Please note that all research records must be retained for a minimum of three years.

Based on the risks, this project requires Continuing Review by this office on an annual basis. Please use the appropriate renewal forms for this procedure.

If you have any questions, please contact Nicole Farnese-McFarlane at (302) 831-1119 or nicolefm@udel.edu. Please include your study title and reference number in all correspondence with this office.

B.2 Subject Questionnaire

University of Delaware
Examining Postural control and Ankle Stability while Wearing the Under Armour® Highlight Cleat in High School Football Players
Subject Questionnaire

Name: _____ Subject Code number: HVT_____

Height (ft' in"): _____ Weight (lbs): _____ DOB (mm/dd/yyyy): _____

Player Position (OFF/DEF) _____

Non-Dominant leg (circle): RIGHT LEFT

Current cleat brand/model (ex. Under Armour® Nitro Low)

_____

How long have you been wearing these pair of cleats?

_____

Have you ever sprained your ankle? YES NO

If yes, please indicate which ankle(s) and how many times you have sprained it.

Right _____ Left_____

Also, please indicate the most recent date you sprained your ankle _____.

Have you ever fractured your ankle? YES NO

If yes, please indicate which ankle(s) and the approximate date the fracture occurred.

_____

Is having your ankle taped a regular part of your practice/game routine?

YES NO

If yes, for how many years have you been having your ankle taped for? _____

Session 1

DATE:
TIME:

Shoe cut: LOW MID HIGH

Taped: YES NO

Trial Number (pre)	Non-D Ant (mm)	Non-D I/E (deg)
1		
2		
3		

BESS Test (Pre)	BESS Score
2-legged (mat)	
Non-dominant (mat)	
Tandem (mat)	
2-legged (foam)	

DATE:
TIME:

Shoe cut: LOW MID HIGH

Taped: YES NO

Trial Number (post)	Non-D Ant (mm)	Non-D I/E (deg)
1		
2		
3		

BESS Test (Post)	BESS Score
2-legged (mat)	
Non-dominant (mat)	
Tandem (mat)	
2-legged (foam)	

Borg: _____

Session 2

DATE:
TIME:

CLEAT: LOW MID HIGH

Taped: YES NO

Trial Number (pre)	Non-D Ant (mm)	Non-D I/E (deg)
1		
2		
3		

BESS Test (Pre)	BESS Score
2-legged (mat)	
Non-dominant (mat)	
Tandem (mat)	
2-legged (foam)	

DATE:
TIME:

Shoe cut: LOW MID HIGH

Taped: YES NO

Trial Number (post)	Non-D Ant (mm)	Non-D I/E (deg)
1		
2		
3		

BESS Test (Post)	BESS Score
2-legged (mat)	
Non-dominant (mat)	
Tandem (mat)	
2-legged (foam)	

Borg: _____