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COMPARATIVE STUDY OF DIVERSE ANKLE SUPPORTS AND RELATED EFFECTS ON FUNCTIONAL PERFORMANCE

MEGAN E. MCFADDEN
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Reviewed and approved* by the following:

W.E. Buckley
Professor of Exercise and Sport Science and Health Education
Thesis Supervisor

Giampietro L. Vairo
Instructor of Kinesiology
Coordinator, Athletic Training and Sports Medicine Research Laboratory
Thesis Co- Supervisor

Jinger S. Gottschall
Assistant Professor of Kinesiology
Honors Adviser

* Signatures are on file in the Schreyer Honors College.

ABSTRACT

COMPARATIVE STUDY OF DIVERSE ANKLE SUPPORTS AND RELATED EFFECTS ON FUNCTIONAL PERFORMANCE

McFadden ME, Buckley WE, Vairo GL: Athletic Training and Sports Medicine Research Laboratory, Department of Kinesiology, University Park PA

Objective: To compare the effects of diverse external ankle supports on functional performance measures in university club-level volleyball players. This research study examined the effects of a traditional lace-up brace and contemporary proprioceptive enhancing ankle support across three functional performance measures. It was hypothesized that the support conditions would have no effect on crossover hop for distance performance and that support conditions would decrease performance on single leg vertical jump height and modified agility t-tests when compared to the control, no brace condition. **Design and Setting:** Ankle support condition served as the independent variable. Dependent variables were functional performance measures, which included the crossover hop for distance, single leg vertical jump height, and modified agility t-test for time. Participants served as their own control and were tested across all three ankle support (none, traditional, contemporary) conditions for the dominant leg. The order of testing conditions was randomized to prevent an order effect. Forty-eight hours separated each testing session. All testing took place in a controlled laboratory. **Participants:** Eighteen (9 men, 9 women) healthy participants (age= 20.1 ± 1.95 years, height = 1.82 ± 0.132 m, mass = 76.9 ± 16.8 kg) from a University's men's and women's club volleyball teams enrolled in the research study. **Measurements:** Crossover hop for distance (cm); Single leg vertical jump height (cm), as measured by the Sargent Jump Test; Agility, as measured by the modified agility t-test (s). A one-way analysis of variance with Tukey's Honestly Significant Difference post hoc test was calculated to determine statistically significant differences among the ankle support conditions. P

< 0.05 denoted statistical significance. **Results**: No statistically significant differences existed among ankle support conditions for the crossover hop for distance (P= 0.924), the single leg vertical jump height (P= 0.650) and the modified agility t-test (P= 0.866) performance measurements. **Conclusion:** External ankle supports do not affect functional performance outcome measures in university club-level volleyball players compared to a control condition. Furthermore, the traditional and contemporary ankle support outcomes were comparable. Thus, it can be surmised that ankle supports do not improve or hinder functional performance. **Word Count:** 345

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Chapter 1

Introduction

Volleyball is a sport that requires frequent, explosive and dynamic movements where players must be able to move very quickly in all directions and use quick steps to aid in their reaching maximum vertical heights when they jump. The nature of these movements have contributed to ankle sprains being the most common acute injuries reported in volleyball players.[1,2] Thus, athletes may opt to wear external ankle supports to stabilize the joint a means to prevent injury. Previous studies[3,4] have investigated the effects of ankle taping and bracing on joint stability, and while they are suggested to assist in preventing injury, less information is available regarding the effects that influence functional sport performance. Hence, the purpose of this research study is to explore the effects of ankle supports on functional performance in a cohort of healthy and young competitive collegiate volleyball athletes.

The two supports that will be used in this study are the standard, lace-up DonJoy brace and the newer Pro Taco support. The Pro Taco is marketed as a lightweight functional ankle support with compressive structures focal to the peroneal tendons, which is proposed to facilitate proprioceptive activity of the ankle evertors lending to joint stability. This marks a clear difference when compared to bulkier traditional ankle braces (like the DonJoy) that function to stabilize the joint through rigid external supports that restrain inversion. However, there are no known research studies comparing the functional performance profiles of each ankle support; hence, the purpose for this investigation.

Specifically, this experiment will focus on profiling responses focal to the crossover hop for distance, single leg vertical jump for height and the modified agility t-test under

different braced conditions. It is hypothesized that wearing an ankle support while completing the crossover hop test will have little to no effect on performance. Research has found that ankle supports have had minimal effects on other sport performance measures and dynamic, forward jumping motions similar to the crossover hop.[5,6] It is hypothesized that wearing an ankle support while performing a test to measure single leg vertical jump height will have a slightly negative effect on participant performance, manifested in a decreased jump height. Other research has shown that, while the effect is minimal, there is a statistically significant decrease in measured single leg vertical jump height across different ankle support types.[7,8] It is hypothesized that wearing an ankle support while running the modified agility t-test will result in a decrease in performance, which will be shown by a slower time for completion of the test. Because the ankle supports are designed to prevent extreme inversions and eversions of the ankle during rapid changes in direction,[7] it is reasonable to assume that wearing a support will inhibit participants' performance. This result is supported by Ambegaonkar et al[9], who observed a significant decrease in agility test performance when the participant was wearing an ankle stabilizer or the ankle was taped. It is hypothesized that, regardless of functional performance measure, the DonJoy brace will have more significant negative effects on performance than the Pro Taco support. The results of this investigation can potentially be used by athletes, coaches and athletic trainers in determining the advantages and disadvantages of using ankle supports in sports.

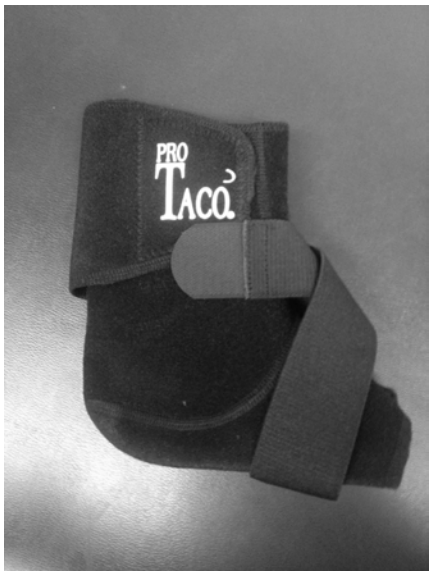
Chapter 2

Methods and Materials

Randomization was used for this experiment, and each participant served as their own control. Each participant was randomly assigned one of the three conditions at each lab visit: control (no bracing), DonJoy (DJO Global, Vista, CA) (Figure 1) ankle brace, or Pro Taco (Topical Gear, Lakeway, TX) (Figure 2) ankle support. Based on Newman et al[10] it was predetermined that the ankle support would only be used on the dominant leg which was described as the leg used to kick a soccer ball for distance and accuracy. Participants were asked to complete three different functional performance tests at three different lab sessions within a 10-week time frame. Each lab session was separated by at least 48 hours. The order in which participants completed these tests was randomized for each lab session to prevent an order effect using the random statistics calculator in Minitab (Minitab 16, Minitab Inc., State College, PA).

Figure 1. DonJoy Ankle Brace

Figure 2. Pro Taco Ankle Support



Participants

Participants were comprised of young and healthy university students from Penn State that participated in competitive collegiate volleyball at the club level. Anthropometric measurements including height, weight, and leg length were collected prior to the first session (Table 1). Each participant identified their dominant leg by choosing which foot he or she would kick a ball with for the most distance and accuracy. Each participant was randomized into a condition and fitted with the assigned ankle support on their dominant leg.

Participants came into the lab and completed all tests at each of the three sessions. Participants were allowed at least 48 hours of rest before their next lab session. For each of the tests, (crossover hop, single leg vertical jump, modified agility t-test) they were given practice attempts before any measurements were recorded. For the crossover hop and single leg vertical jump tests participants were barefoot to eliminate shoe-type as a confounding variable in the experiment. For the modified agility t-test, participants wore sneakers to reduce the risk of injury, but were all instructed to wear volleyball sneakers, which have similar traction patterns to reduce the effects of sneakers on the recorded testing data.

Table 1: Participant Demographic and Anthropometric Data

	M ± SD
Participants	18
Sex (Men/Women)	9/9
Age (years)	20.1 ± 2.01
Height (m)	1.82 ± 0.14
Mass (kg)	76.9 ± 17.3
BMI (kg/m^2)	23.1 ± 3.47
Dominant Leg (Right/Left)	15/3
Dominant Leg Length (cm)	93.1 ± 9.22

Laboratory Techniques

Crossover Hop for Distance

The crossover hop is a test that measures functional performance and has been shown to have both high measurement reliability in a healthy population.[11,12] The goal of the crossover hop is for the participants to cover as much distance as possible with three hops. With each hop, the participant must cross over a pre-marked course that is 20 cm wide by 900 cm long. The participant was instructed to stand on their dominant leg with the lateral portion of the foot in line with the contralateral edge of the course, with the most tip of their longest toe touching the edge of the starting line. The participant was then instructed to try to cover the most distance possible by completing three consecutive hops, crossing over the course with each hop. If the participant touched the ground with the non-stance foot during the trial, the participant did not clear the lateral sides of the course, and/or the participant paused for too long in between each hop, the trial was thrown out and repeated. Distance covered was measured using a tape measure. Three practice trials followed by three trials were completed with a minute of rest between each trial. This measure was normalized to dominant leg length, and the average of the three test trials was calculated and used as the final measurement.

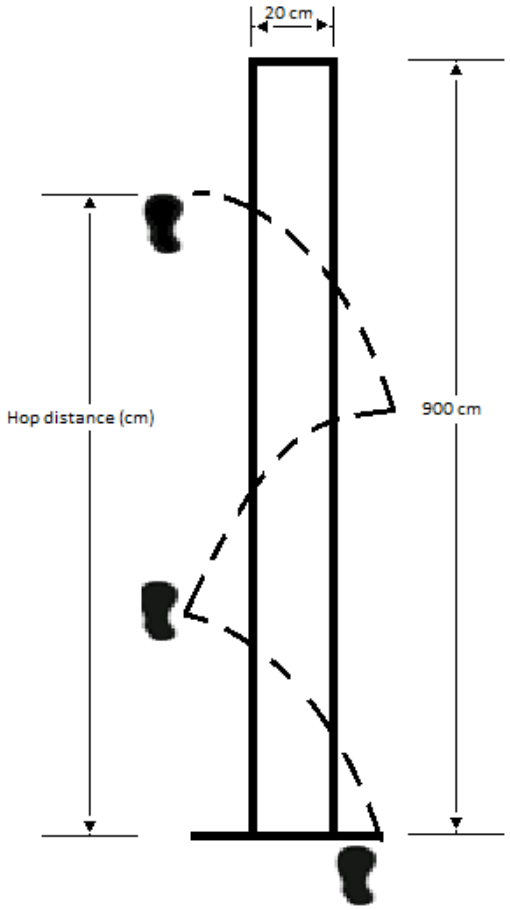


Figure 3. Crossover Hop for Distance

Single Leg Vertical Jump for Height

The single leg vertical jump has been reported to have both measurement and test-retest reliability. [13,14] We measured the single leg vertical jump using the Sargent Chalk Jump method, which has been shown to have good reliability and validity.[9] Participants were instructed to stand against a wall with their heels on the ground, and extend their arm on the same side as the dominant leg up the wall as far as possible. They then marked their reach height (the highest point the middle fingertip reached on the wall) with a piece of chalk. The participants were then instructed to stand only on their dominant leg and jump as high possible using a self-selected countermovement without allowing their other foot to touch the ground. The peak height jump, defined as the highest point reached by the participant's middle fingertip after jumping, was marked on the wall with chalk as well. The distance between the standing reach height and peak jump height was be measured in centimeters and served as the single leg vertical jump height.[9] Participants were allowed three practice jumps with 30 seconds of rest in between each jump. They then completed three measured trials with 30 seconds of rest between each jump. The practice jumps and measured trials were separated by one minute. [14] The mean of the three test trials was calculated and used as the participants' single leg vertical jump height. If the participants' non-dominant leg touched the ground at any point during the take off, jump, and/or landing the trial was removed and repeated.

Figure 4: Single Leg Vertical Jump Height

Modified Agility T-Test

The modified agility t-test measures speed and ability to change direction, and assesses participant agility[15]. According to Sassi et al [15] this test has been found to have high measurement and test-retest reliability for both men and women.

The modified agility t-test requires a course of four cones. Two cones were placed five meters apart from one another (cones A and B). Two more cones (C and D) were be placed on either side of the far cone (B) at a distance of two and a half meters, forming a course that looks like the letter "T". Participants started with both feet behind cone A. They then sprinted forward to cone B and touched the base of the cone with their right hand. Next, participants shuffled to their left to cone C and touched the base with their left hand. Participants then shuffled to their right to cone D and touched the base with their right hand. They then shuffled back to their left to cone B and touched its base. While shuffling to either side participants must have been facing forward and were not allowed to have their feet cross over one another. After touching the base of cone B, participants remained facing forward and back pedaled to cone A, the original start of the course. The goal of this test was to complete the entire testing course in the shortest amount of time possible.

Each participant performed two practice trials separated by three minutes each. The participants also completed two measured tests separated by three minutes each and five minutes apart from the practice trials. The faster of the two measured tests was recorded. If the participants failed to touch the base of each cone, faced the wrong direction, and/or had their feet cross over one another during the test, that trial was be thrown out and repeated. [15]

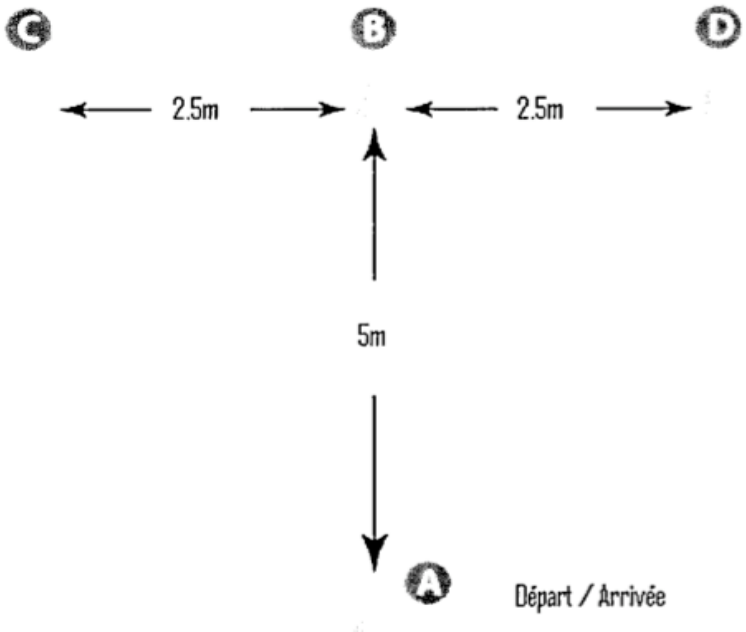


Figure 5. Modified Agility T-Test[15]

Statistical Analyses

Evaluation of all data was conducted using Minitab software for data analysis. Statistical analyses of individual functional performance test means (crossover hop for distance, single leg vertical jump height, and modified agility t-test) across three separate bracing conditions (baseline/no brace, DonJoy ankle brace, Pro Taco ankle support) were performed. Descriptive statistics, such as group means and standard deviations were calculated for the dependent variable. A one-way analysis of variance (ANOVA) with Tukey's Honestly Significant Difference (HSD) post hoc test was calculated to determine statistically significant differences among the baseline and DonJoy ankle brace and Pro Taco ankle support measures for the dominant leg. Inspection of the standardized residuals was conducted to verify the data meet the necessary assumptions for ANOVA. An *a priori* alpha level of $P \leq 0.05$ indicated statistical significance.

Percent difference and effect size between each bracing condition was also calculated from the group means and standard deviations. Effect sizes were interpreted in a manner such that values ≤ 0.40 signified weak, values ranging from 0.41 to 0.70 signified moderate and values ≥ 0.71 signified strong effects.[16]

Chapter 3

Results

Crossover Hop For Distance

No statistically significant differences were found with the crossover hop for distance among bracing conditions (P= 0.924). Furthermore, weak effect sizes were found among all condition comparisons (Table 2). Based on these results, it can be inferred that wearing a brace had no significant effect on participant performance for the crossover hop.

Table 2: Crossover Hop Measures

Brace Condition	**Distance (% Leg Length, cm)**	**% diff**	**95% *SCI* (Upper, Lower)**	***d***
Control (No Brace)	26.081 ± 6.708			
v DonJoy	26.326 ± 6.807	1.788	(-5.178, 5.668)	0.070
v Pro Taco	26.951 ± 6.726	0.558	(-4.553, 6.293)	0.022
DonJoy v Pro Taco		2.346	(-4.798, 6.048)	0.093

Values are mean ± standard deviation;
SCI = simultaneous confidence interval; v = versus; % diff = percent difference;
d = Cohen's effect size;
* denotes statistical significance

Single Leg Vertical Jump Height

No statistically significant differences existed for the single leg vertical jump height test (P = 0.650). Moreover, weak effect sizes existed across all associated conditions (Table 3). Based on these results, we can infer that the DonJoy brace and Pro Taco support have no significant effects on single leg vertical jump height.

Table 3: Single Leg Vertical Jump Height Measures

Brace Condition	**Jump Height (cm)**	**% diff**	**95% *SCI* (Upper, Lower)**	***d***
Control (No Brace)	31.163 ± 7.415			
v DonJoy	28.624 ± 8.233	9.131	(-9.106, 4.029)	0.335
v Pro Taco	29.820 ± 8.805	5.043	(-7.910, 5.225)	0.188
DonJoy v Pro Taco		4.092	(-5.371, 7.764)	0.146

Values are mean ± standard deviation;
SCI = simultaneous confidence interval; v = versus; % diff = percent difference;
d = Cohen's effect size;
* denotes statistical significance

Modified Agility T-Test

No statistically significance differences were found among conditions for the modified agility t-test (P = 0.866) with corresponding weak effect sizes (Table 4). These results allow us to infer that the bracing conditions observed in this study had no significant effects on performance of the modified agility t-test.

Table 4: Modified Agility T-Test Measures

Brace Condition	**Time (s)**	**% diff**	**95% *SCI* (Upper, Lower)**	***d***
Control (No Brace)	7.739 ± 0.819			
v DonJoy	7.680 ± 0.708	1.705	(-0.7270, 0.6093)	0.157
v Pro Taco	7.828 ± 0.948	1.143	(-0.5791, 0.7572)	0.107
DonJoy v Pro Taco		2.849	(-0.5202, 0.8161)	0.264

Values are mean ± standard deviation;
SCI = simultaneous confidence interval; v = versus; % diff = percent difference;
d = Cohen's effect size;
* denotes statistical significance

Chapter 4

Discussion

The results of this study show that the DonJoy brace and Pro Taco ankle support had no significant effects on participant performance on the crossover hop for distance when compared to one another and a control. This outcome supports the null hypothesis, which was our anticipated response based on the results of preceding similar experiments. For example, previous research has studied the effects of external ankle supports on other distance- related jumping tests, including the standing long jump and standing broad jump, and found that ankle supports had no significant effect on participants' performance.[16, 17] Similarly, we found that external ankle supports had no significant effect on performance of the crossover hop for distance. Based on this and prior related data we could potentially infer that wearing ankle supports does not have any negative effects on jumping performance, which is an essential volleyball skill. The standing long jump, broad jump, and crossover hop are all tests that require vertical and horizontal jumping movements which accurately reflect common volleyball movements. Although all tests asses common fundamental skills, the fact that data shows ankle bracing has no effect on these diverse assessments[16, 17] strongly suggests that dynamic jumping movements will not be hindered or enhanced by wearing external supports. However, continued study on the effects of ankle supports on specific volleyball tasks such as a spike approach, which involves rapid, consecutive movements to cover a certain distance is necessary to definitively confirm this assertion.

Contrary to the second stated hypothesis for this experiment, the data revealed that the bracing conditions did not affect outcome measures on single-leg vertical jump height and time on the modified t-test for agility. Similar to our results, previous research has shown that the

DonJoy Ankle Ligament Protector (ALP), semi-rigid braces, and soft braces also had no significant effects on single-leg vertical jump height.[18,19] However, our results differ from other studies that have found that lace-up braces, similar to the DonJoy brace used in this study, cause significant decreases in single-leg vertical jump height.[16,20] Furthermore, a meta-analysis of the current associated literature[7] indicates that ankle braces tend to decrease performance on this functional performance test. The variation of these results could potentially be a result of the functional performance tests used to measure jump height. Research that supports the results of this study assessed vertical jump height using similar methods that measured the distance between participants' standing reach height and jump height indicated by marks on the wall[5,20] as well as running vertical jump height measured by a Vertec device.[21] Research that has found significant decreases in vertical jump performance has measured single leg vertical jump height (in inches) with bilateral bracing conditions using the Sargent Jump test[20], vertical jump height using force plate data,[18] or did not report the specific test performed.[17] Thus, potential discrepancies between our study and the current literature could reflect differences in how vertical jump height was collected and determined. Studies that have reported a decrease in vertical jump height while wearing an external ankle brace also observed varsity athletes[6] and used a more rigid brace[18], indicating that the effects may vary based upon brace type and participant skill level. Therefore, a more standardized procedure may be useful in making such an assessment more accurate and lend to better outcome comparisons among related research studies. Hence, we conclude that the external ankle supports used in this study do not hinder single-leg vertical jump height compared to no brace or when compared to one another. However, additional research in this body of work is necessary to confirm or refute this particular statement.

No significant differences were also found between ankle support conditions with performance on the modified agility t-test. These results complement previous research that studied the effects of ankle braces on similar agility measures and found comparable results.[5,6]

Accordingly, ankle braces have been shown to have no significant effects on performance of the Southeast Missouri (SEMO) [20], S180 [22] and T-Test [22] for agility. Newman et al[23] demonstrated that there was no statistical difference between bracing on the dominant leg and bilateral bracing on performance of the agility test used in their study, and that neither bracing condition had a significant effect on the agility course completion time, further supporting the findings of this current study. Based on the current study's results and related literature, it can be assumed agility performance will not be affected by wearing external ankle supports. This finding is important for coaches and athletes because it implies that making rapid movements forward, backward, and laterally, which mimic quick changes in direction will not be hindered or improved by wearing external ankle supports.

There were, however, limitations to this study. All participants were members of the Penn State men's or women's club volleyball teams. While this population was appropriate for this study, all of the participants are of the same relative skill area and have similar volleyball experience. Because this is such a specific population, it is possible that the results found in this study may not be applicable to players of all ages and skill levels. Future studies may want to assess the effects that external supports, specifically the Pro Taco, have on performance measures in other populations of athletes prone to ankle injuries including basketball, soccer, and rugby players. It may also be beneficial to repeat these testing measures using volleyball players of different demographics (middle school, high school, collegiate varsity, and professional) to determine if the effects of external ankle supports on functional performance measures vary depending on skill level.

Another limitation to this study is that only the participants' dominant legs were tested. It is possible that the effects of external supports would show different results if tested on participants' non-dominant legs. Testing these bracing conditions on both dominant and non-

dominant legs may want to be considered for future research, and could potentially strengthen the conclusions drawn from this study.

Participants were also required to wear sneakers when completing the modified agility t-test to reduce the chances of losing their footing or slipping on the gym floor (negatively affecting their completion time) and to reduce the risk of injury. All participants were instructed to bring and wear their own volleyball sneakers that they would use when practicing and competing to all testing sessions. While volleyball shoes may all be similar and serve the same purpose, differences in shoe weight, design, and manufacturing could have affected performance outcomes for this test. Additionally, the degree of how worn in or damaged the sneakers were could have varied between participants affecting outcome measures.

All of our participants were healthy athletes who had not experienced previous trauma to the lower extremities. It may be beneficial to test the effects of these ankle supports on participants who have suffered from ankle injuries. The tests that were used in this study could also be modified to better simulate game-like situations and thus more accurately assess the effects of ankle supports on volleyball-specific performance.

From a clinical standpoint, the results of this study are beneficial to athletes who choose to wear these specific ankle braces. This research has shown that the external ankle supports have no significant effects on functional performance measures. This implies that athletes can choose their ankle support based on personal preference and comfort level without experiencing negative effects on performance. Subsequently, it appears as if neither brace offers any benefit to improving functional performance as well. This information may also be useful to strength and conditioning coaches as well as athletic trainers who can use these results to prescribe ankle braces to their athletes based on support and function without seeing decreases in athletic performance.

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Literature Review

Lateral ankle sprains are among the most common type of injury seen in volleyball players.[1, 2] To reduce the risk for injury, many athletes, coaches, and athletic trainers wear or recommend external ankle braces to provide additional support and stability. While these braces have been shown to reduce the occurrence of injury to the lower extremities in athletic populations[3, 4], it is possible that wearing an ankle brace could result in performance changes. This review examines current literature and the date it presents regarding the effects of ankle braces on functional performance measures.

Functional Performance

Vertical Jump

Many different studies have examined the effects of various ankle supports on jumping performance. Rosenbaum et al[18] found that semi-rigid and soft ankle braces had no significant effects on vertical jump performance, but that a rigid brace had significant negative effects on jump height. The DonJoy Ankle Ligament Protector (ALP) ankle brace and ankle taping were shown to have no significant effects on a four-step approach vertical jump when compared to unbraced conditions.[19] Research has also shown that athletic taping of the ankle results in a significant decrease in vertical jump height when compared to un-taped jumping, [6, 23] and that ankle taping resulted in the largest decrease in vertical jump performance.[7] Similarly, vertical leap height decreased when study participants wore a Swede-O lace-up brace and a ProCare Kallassy ankle support.[6, 20] Three different lace up braces (Swede-O, McDavid, and NewCross) were shown to cause decreases in jump height when completing the Sargent Chalk Jump Test, but only

the NewCross brace decrease of 5.4% was statistically significant.[20] Research has also found that participants perceive decreased performance capacity when wearing ankle supports.[6] Meta analyses have found that, in general, the use of ankle support devices have negative effects on vertical jump performance.[3,24] This reported decrease in vertical jump height has been attributed to the reduced flexion, extension, eversion, and inversion of the ankle joint when wearing ankle braces/supports. [3,24] Thus, the review of the literature suggests that ankle taping and bracing has detrimental or non-significant effects on vertical jump height.

Agility

Many different tests can be used to assess agility. Paris[20] measured the time taken to complete the South Eastern Missouri (SEMO) agility test across four different ankle support conditions (taping support, New Cross brace, Swede-O brace, McDavid brace) and found no statistically significant differences in time between braced and non-braced conditions. Putnam[22] found that the McDavid 199 Lightweight ankle brace had no significant effect on performance of the S180 and T-test for measuring agility. It was also reported that the Aircast Air Stirrup, Ligafix Air Brace, Malleoloc brace, and ankle taping all had no significant effect on performance of the Japan agility test.[25] Many studies have utilized a shuttle test to measure agility. These studies have found that the Active Ankle Training, AirCast Sport Stirrup, DonJoy Rocketsoc, Swede-O, and ProCare Kallassy ankle braces had no significant effects on the shuttle-run agility test.[5,6,8,26,27] It has been demonstrated that the Aircast Stirrup brace caused significant decreases in performance on a softball base-running agility test, but that the DonJoy ALP and Swede-O braces had no effects on the same test. [19]

ProCare Kallasy, AirCast Stirrup, AirCast Training, and Active Ankle braces have been shown to have no significant effects on a sport-related agility test when compared to non-braced

conditions. [6,26, 28] Semi-rigid, and soft ankle braces also do not have a significant effect on a sports-related high-intensity, short duration agility test.[18] However, Beriau et al[28] found that subjects performed an agility test faster while wearing the Aircast Training Brace than when wearing the DonJoy Ankle Ligament Protector, demonstrated that different types of braces can have significant effects on agility performance.

Speed

Studies have also looked at the effects of ankle bracing on running speed. Paris[20] found that tape, Swede-O and New Cross ankle bracing had no significant effects on running speed in a 50-yard sprint. Research has also shown that there are no significant effects of the McDavid 199 Lightweight, Kallassy, DonJoy ALP, Aircast Sport Stirrup, and DonJoy Rocketsoc ankle braces on 40-yard sprint speeds. [6,22,29,30] Use of the Swede-O brace as well as ankle taping have been found to have significantly negative effects on the 40-yard sprint, with speed decreases of 3.5% and 3.2%, respectively. [6] The Active Ankle training and Aircast Sport Stirrup were shown to have no significant effects on 80-feet sprint speeds.[26] Greene and Wright[19] found that Air-Stirrup braces slightly decreased base running speed in softball players, but that the DonJoy ALP and Swede-O braces had no effects on speed.

Sport-specific performance

Basketball

MacKean[8] et al studied the effects of the Active Ankle, Aircast Air Stirrup, Swede-O Universal, and athletic tape on functional performance in female basketball players. Participants

varied in basketball skill level, and completed three functional performance tasks- vertical jump, jump shot test, and sprint drill. The results showed that the basketball players jumped significantly higher under no brace conditions than when wearing athletic tape at the ankle whereas the bracing conditions showed no significant differences to un-braced conditions. The study found that jump-shot accuracy was significantly increased when having a taped ankle when compared to the Swede-O brace condition. Ankle support and bracing was found to have no significant effect on sprint time.

Pienkowski[5] et al looked at the effects of the ProCare Universal, ProCare Kallassy, and Aircast Air-Stirrup ankle braces on basketball performance in male high school basketball players. Participants completed a vertical jump test, standing long jump test, cone run, and 18.3 meter shuttle run to assess functional performance. The results indicate that none of the three ankle braces significantly affected any of the functional performance measures. It has also been reported that male and female basketball players wearing the Active Ankle Training Brace and Aircast Sports Stirrup experienced no significant effects on performance of the vertical jump, 80-foot sprint, shuttle run and 4-point run.[31] Similarly, the DonJoy Rocketsoc did not alter performance on a 24m sprint, a 12m shuttle run and a vertical jump in male and female varsity and junior varsity high school basketball players.[31]

Volleyball

Greene and Hillman[21] observed the effects of external ankle supports on a four-step approach vertical jump height performance of female intercollegiate volleyball players. Participants completed three separate trials wearing no support, athletic tape at the ankle, or the DonJoy ALP brace. Although the research found that vertical jump height was highest in the un-

braced condition, the difference was not statistically significant, meaning the ankle bracing had no significant effects on performance.

Soccer

Putnam et al[22] found that recreational soccer players experienced no performance differences when wearing a McDavid 199 Lightweight ankle brace. The study used accuracy shooting at a target, 40-yard dash, S180° run, and T-test to assess functional performance. No statistically significant changes between braced and un-braced conditions were found.

Paris[20] studied the effects of ankle braces on functional performance in twenty-five elite, male soccer players. This research found that, compared to un-braced conditions, the participants vertical jump height was significantly reduced when wearing a NewCross ankle brace. Decreases in vertical jump height were also noted for tape, Swede-O, and McDavid brace conditions, but these were not statistically significant. The effects of the four ankle supports on performance of the SEMO Agility test and fifty yard sprint were also not statistically significant, shwoing that there was no observed statistical difference on performance between un-braced and braced conditions.

Population differences

Collegiate Athletes vs. High School Athletes

Research shows some differences between high school and collegiate athletes regarding the effects of ankle braces on functional performance. Bocchinfuso et al[26], Macpherson et al[27],

and Pienokowski[5] et al, all found no statistically significant effects of ankle bracing on functional performance in high school athletes. However, MacKean et al[8] and Burks et al[3] observed collegiate athletes and found that vertical jump height was significantly reduced when athletes wore ankle tape.

Recreational Athletes

Beriau et al[28] examined the effects of Aircast Sports Stirrup, Aircast Training brace, Swede-O brace, and DonJoy Ankle Ligament Protector on high-school athletes' completion of an agility course. They found that the times taken to complete the agility course while wearing ankle braces were not significantly different from the un-braced times. Putnam[22] similarly found that wearing ankle braces did not significantly affect soccer performance measures in recreational athletes. Meta-analyses have revealed that the effects of ankle bracing on vertical jump height, speed, agility, and broad jumps are insignificant in non-elite populations.[7]

Gender Differences

Some studies used a combination of male and female participants. In these studies, it was not reported that the results were significantly different based on gender. [3, 22, 26, 28,31] In studies that observed only one gender group, the results were fairly similar and generally reported that ankle braces had no significant effects on functional performance [8,21, 27] However, negative effects on vertical jump height were noted in two studies that only used male participants. [6, 20]

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Appendix A: Recruitment Materials

Eligibility Screening Questionnaire

PENNSTATE

1855

Title of Project: Comparative Study of Competitive Ankle Supports and Their Effects on Balance and Functional Performance

Principal Investigator: Sayers John Miller, PhD, PT, ATC
W.E. Buckley, PhD, ATC

Other Investigator(s): Giampietro L Vairo, MS, ATC

Screening Checklist: Member of the Penn State Men or Women's Varsity or Club Volleyball teams.

Participant Identification Number: _____

As a general health screen, you must be able to answer 'YES' to the following questions.

1)Are you between 18 and 25 years old **Yes** **No**

2) Are you recreationally active (defined as individuals engaging in physical activity at least three days per week for 30 minutes over the past six-months)? **Yes** **No**

3) Do you have a history of participation on a competitive volleyball team? **Yes** **No**

4) Do you speak English? **Yes** **No**

As a general health screen, you must be able to answer 'NO' to the following questions.

5) Have you followed a formal rehabilitation program under supervision of a physical therapist or athletic trainer? **Yes** **No**

6) Do you have pain above 3 out of 10? **Yes** **No**

7) Have you sustained injury to your back or have a history of back problems? **Yes** **No**

8) Have you sustained any traumatic injury to the lower extremity within the last 6 months? **Yes** **No**

9) Are you currently experiencing any abnormal swelling of the lower extremities? **Yes** **No**

10) Are you diabetic or do you suffer from peripheral neuropathy? **Yes** **No**

11) Have you sustained a concussion within the past six months? **Yes** **No**

12) Are you currently in the third trimester of pregnancy? **Yes** **No**

Flyer

Athletic Training Research Laboratory

PENNSTATE

1855

Research Volunteers Needed

Are you interested in learning more about effects of ankle supports?
If so, you may be interested in participating in our research study.

Measurements: single leg balance (dynamic and static), and functional performance tests.

Purpose: Study the effects of competitive ankle supports on single leg balance and functional performance in volleyball players.

Three (3) 60-120 minute sessions. All sessions will be in the Athletic Training Research Laboratory in 21D&E Recreation Building over ten (10) weeks.

Requirements:

- Men and women ages 18 – 25 years old (*If you are under the age of 18 years old, parental or legal guardian consent is required for your participation*)
- Good general health
- Not overweight
- Physically-active member of the men or women's varsity or club volleyball team.

Dr. W.E. Buckley, Dr. Sayers John Miller and John Vairo
Department of Kinesiology

For more information, contact John Vairo at
glv103@psu.edu or 814-865-2725

Verbal Consent

PENNSTATE

1855

Title of Project: The Effect of Ankle Supports on Single Leg Balance and Functional Performance in Volleyball Players

Principal Investigator: Sayers John Miller, PhD, PT, ATC; W.E. Buckley, PhD, ATC

Project Coordinator: Giampietro L Vairo, MS, ATC

Research Support: Megan McFadden, Mark Capuzzi

Script: Members of the Penn State Men's and Women's Club and Varsity Volleyball teams (18-25 years old)

Hello, my name is (*Penn State Institutional Review Board-approved investigator*) and I work with the Athletic Training Research Laboratory at Penn State. I am currently looking for research volunteers and was wondering if you would be interested in participating or at least hearing more about this study. I am looking for a group of participants who are 18 to 25 years old, play competitive volleyball and are members of the men's or women's varsity or club volleyball teams. If you are under the age of 18 years old, parental or legal guardian consent is required for your participation in this research study. Participants in this research study should be in good general health, not overweight and physically-active. If you are undergoing physical therapy or sports rehabilitation under the supervision of a physical therapist or athletic trainer you will not be eligible to participate. I will be examining the effects of ankle supports on balance and functional performance in athletes. If you are interested in participating, you would be required to come to the Athletic Training Research Lab in 21D&E Recreation Building for two times a week for ten weeks. All sessions will last approximately 2 hours. During each visit you will be asked to perform three balancing exercises and three functional tests. During these tests you will be wearing a DonJoy ankle support, Pro Taco ankle support, or no support at all, depending on the group to which you are randomly assigned. During the visits over the next ten weeks you will only undergo your designated treatment. As a participant we will be happy to provide you with your specific measurement results. If you have any questions or need to get in touch with me for any reason, my phone number is (*respective Penn State Institutional Review Board-approved investigator*) and my e-mail is (*respective Penn State Institutional Review Board-approved investigator*). Thank you.

Appendix B: Written Informed Consent Form

Informed Consent Form

Informed Consent Form for Biomedical Research
The Pennsylvania State University
ANKLE SUPPORT PARTICIPANTS
(18-25 years old)

Title of Project: Comparative Study of Competitive Ankle Supports and Their Effects on Balance and Functional Performance

Principal Investigator: Sayers John Miller, PhD, PT, ATC
Assistant Professor of Kinesiology
Department of Kinesiology
146 Recreation Building
University Park PA 16802
sjm221@psu.edu; 814-865-6782

Project Coordinator: Giampietro L. Vairo, MS, ATC
Instructor of Kinesiology
PhD Candidate in Kinesiology
Department of Kinesiology
146 Recreation Building
University Park PA 16802
glv103@psu.edu; 814-865-2725

Co-Investigator: W.E. Buckley, PhD, ATC
Professor of Kinesiology
Department of Kinesiology
146 Recreation Building
University Park PA 16802
web5@psu.edu; 814-863-9730

Research Support: Megan E. McFadden
Undergraduate Schreyer Honors College Student
Department of Kinesiology
146 Recreation Building
University Park PA 16802
mem5491@psu.edu; 814-865-2725

Mark Cappuzi
Undergraduate Schreyer Honors College Student
Department of Kinesiology
146 Recreation Building
University Park PA 16802
mjc5527@psu.edu; 814-865-2725

1) Purpose of the study: The purpose of this research is to study the effects of competitive ankle supports on singleleg balance and functional performance specifically in volleyball players. The two ankle supports that will be used in this study are the DonJoy and Pro Taco supports. All participants in this study will be healthy students between the ages of 18 and 25. For each lab session, participants will either wear a DonJoy support or Pro Taco support or wear no support at all. Participants will be randomly assigned to one of these groups for each lab session and will be assigned to each group within the time span of the study.

2) Criteria for inclusion of participants: You are being invited to participate in this research study because you are healthy, physically active and between the ages of 18-25 years old. You have also in good physical health and are a member of the Pennsylvania State University's men's or women's club or varsity volleyball teams.

3) Procedures to be followed: If you choose to participate in this research study, you will be asked to perform the following procedures:

Procedures

A. We will begin the study by randomly assigning you into a test group. If you are assigned to a group that will be wearing an ankle support, we will fit you with one before we begin. After you are fit with a support, you will be asked to perform a total of six tests.

B. You will be asked to perform a single leg balance stance task. During the execution of this test, a surface electromyography (EMG) will be attached to the peroneal muscles. You will be standing on one leg barefoot while maintaining balance for a ten second trial with eyes open and then eyes closed. You will be instructed to stand as still as possible with their arms crossed over their chest while maintaining 45 degrees of knee flexion and 30 degrees of hip flexion of the non-stance leg. Measures of balance will be taken using a force platform which is hooked up to a computer.

C. You will be asked to perform another single leg balance task called the Star Excursion Balance Test. During the execution of this test, a surface electromyography (EMG) will be attached to the peroneal muscles. For the Start Excursion Balance Test you stand in place on one leg in the middle of the star and reach as far as possible with your other leg in eight different directions: front, same-side diagonal front, same-side, same-side diagonal back, back, opposite-side diagonal back, opposite-side, opposite-side diagonal front. You will be given four (4) practice trials and complete three (3) testing trials. You will be given a five (5) minute rest period between the practice and test trials. A picture of the Star Excursion Balance Test is below.

D. You will be asked to perform a functional test called the Crossover Hop Test. For the test, you will be asked to stand on one leg to one side of a line. You will then complete three consecutive hops on that leg without pausing. With each hop, you have to cross over to the other side of the line. Your goal is to cover the most distance you can with the three hops. You will be given three practice hops followed by three measured trials. Each hop will be separated by a one minute rest period. A picture of the Crossover Hop Test is below.

E. You will be asked to perform another functional test to asses your vertical jump height. You will stand against a wall with one hand raised to measure your standing reach. You will then be asked to stand on one leg and attempt a vertical jump, aiming to reach as high up the wall as possible. The distance between your standing reach and jump height will be calculated and serve as you single leg vertical jump measurement. You will be given three (3) practice jumps and complete three (3) testing jumps. Each jump will be separated by a one (1) minute rest period.

F. You will be asked to perform another functional test call the T-Test to assess agility and speed. There will be a set of four cones arranged in the shape of a T with a distance of five (5) or ten (10) yards between them. You will start at a cone at the bottom of the T. When the researcher says "GO" you will be asked to sprint ten (10) yards forward to the next cone and touch the base. You will then turn left and shuffle five (5) yards to the next cone and touch the base. You will then turn right and shuffle ten (10) yards to the far cone and touch the base. You will then turn left and shuffle five (5) yards to the middle cone, touch the base, and then back pedal ten (10) yards to the starting cone. The time required to complete this test will be recorded. You will be given one (1) practice trial and two (2) testing trials. Each trial will be separated by three (3) minutes. A picture of the T-Test is below.

G. After you're done with testing procedures A through G you have finished your first test session. You will be asked to come back to the Athletic Training Research Lab in 21D&E Recreation Building two more times within the next 10 weeks. You will perform testing procedures A through G at all other testing sessions to assess your single leg balance and functional performance.

4) Discomforts and risks: The discomforts and risks with participation in this type of research study are minimal. The tests used are within expected ranges for physically active people. To lessen the chance of injury, you will also be shown how to properly perform every task in the experiment. Possible discomfort may consist of delayed onset muscle soreness 48 to 72 hours following testing. As with any research study, it is possible that unknown harmful effects may happen. However, the chance for injury in this type of research study is minimal and includes muscle strains, ligament sprains, or aggravation of previously experienced chronic ankle instability symptoms. We will take every possible effort to watch for and help prevent against any discomforts and risks.

5) Benefits: There is no direct benefit to you from participating in this research study. The benefits to society include recognizing potential advantages from using ankle supports while participating in volleyball related activities.

6) Duration/time of the procedures and study: All treatment sessions during the ten weeks will be at least 48 hours apart and will last between one to two hours each. All testing takes place in the Athletic Training Research Laboratory in 21D&E Recreation Building on Penn State's University Park Campus.

7) Statement of confidentiality: Your participation in this research study is strictly confidential. All research records from your participation in this study will be kept confidential similar to medical records at your doctor's office or hospital. All records will be secured in locked file cabinets at the Athletic Training Research Laboratory. A unique case number will indicate your identity on research records. In the event of any publication resulting from this research study, no personally identifiable information will be disclosed. Penn State's Office for Research Protections, the Institutional Review Board and the Office for Human Research Protections in the Department of Health and Human Services may review records related to this research study. Penn State policy requires that research records be kept for a minimum period of three years at the end of the study. Three years following the end of this research study all records will be appropriately destroyed.

8) Right to ask questions: Please contact Sayers John Miller at (814) 865-6782 with questions, complaints or concerns about this research. You can also call this number if you feel this study has harmed you. If you have any questions, concerns, problems about your rights as a research participant or would like to offer input, please contact Penn State University's Office for Research Protections at 814-865-1775. The Office for Research Protections cannot answer questions about research procedures. Questions about research procedures can be answered by the research team. Referral information for Penn State students who wish to seek additional assistance includes the following:

Penn State University Health Services
Student Health Center
University Park PA 16802
814-863-0774

If you are not a Penn State student, please contact your Primary Care Physician for additional assistance.

9) Voluntary participation: Your decision to be in this research study is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. Refusal to take part in or withdrawing from this research study will not involve penalty or loss of benefits you would receive otherwise. You may be removed from this research study by investigators in the event you cannot complete the testing procedures.

10) Injury Clause: In the unlikely event you become injured as a result of your participation in this research study, medical care is available. If you become injured during testing procedures the investigators listed on this informed consent form will provide you with appropriate first aid care and instruct you on proper steps for follow-up care. If you were to experience any unexpected pain or discomfort from participating in this research study after leaving the Athletic Training Research Laboratory please contact Sayers John Miller immediately at (814) 865-6782. If you cannot reach Dr. Miller please leave him a voicemail and contact your doctor.

If you are a Penn State student and cannot reach Dr. Miller or your doctor please leave them voicemails and contact Penn State University Health Services at:

Student Health Center, University Park PA 16802
814-863-0774

If you are not a Penn State student and cannot reach Dr. Miller or your doctor please leave them voicemails and contact your private medical provider.

It is the policy of this institution to provide neither financial compensation nor free medical treatment for research-related injury. By signing this document, you are not waiving any rights that you have against The Pennsylvania State University for injury resulting from negligence of the University or its investigators.

You must be 18 years of age or older to take part in this research study. If you are under the age of 18 years old, your parent or legal guardian must also agree to your participation in this research study. If you agree to take part in this research study and the information outlined above, please sign your name and indicate the date below.

You will be given a copy of this signed and dated consent form for your records.

_____ _____

Participant Signature Date

_____ _____

Person Obtaining Consent Date

Appendix C: Data Collection Materials

Anthropometric Data and Data Collection Sheet

Participant I.D. _____

Age: _____ Sex: _____

Weight (kg): _____ Height (cm): _____

Dominant Leg Length (cm): _____ Non-Dominant Leg Length (cm): _____

Brace Condition (circle): No Brace DonJoy Pro Taco

Functional Measures

Crossover Hop

Trial 1	**Trial 2**	**Trial 3**
cm	cm	cm

Single Leg Vertical Jump

Trial 1	**Trial 2**	**Trial 3**
cm	cm	cm

Modified Agility T-Test

Trial 1	**Trial 2**
s	s

Appendix D: Figures

Single Leg Vertical Jump for Height

Crossover Hop for Distance

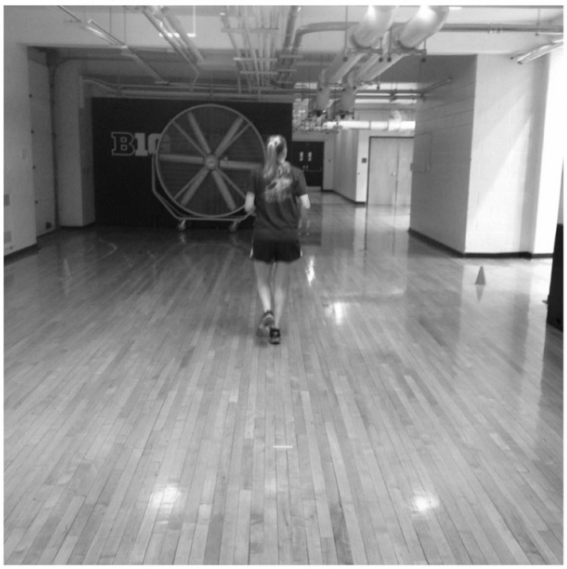
Progression of the Crossover Hop

Modified Agility T-Test

1. Participant runs forward, touches base of cone.

2. Participant shuffles left, touches base of cone

3. Participant shuffles right, touches base



4. Participant back pedals through the start

ACADEMIC VITA

Megan E. McFadden
15040 Carter Road
Philadelphia, Pennsylvania 19116
mem5491@gmail.com

Education

- Bachelor of Science Degree in Movement Science, The Pennsylvania State University
  Spring 2013
  Honors in Kinesiology
  Thesis Title: Comparative Study of Diverse Ankle Supports and Related Effects on Functional Performance
  Thesis Supervisor: Dr. WE Buckley

Related Experience

- Volunteer Physical Therapy Observation & Shadowing
  NovaCare, Northeast Philadelphia, PA, Summer 2011
  Bucks Physical Therapy, Richboro, PA, Summer 2012

Honors and Awards

- College of Health and Human Development Scholarship
  Pennsylvania State University, Fall 2009

- Union Scholarship
  Local Union, Fall 2009

Activities

- Penn State Women's Club Volleyball
  President, Fall 2010- Spring 2012
  Vice President, Fall 2012- Spring 2013
  Member, Fall 2009-Spring 2013

- Penn State Dance Marathon
  Dancer, THON 2012
  Club Volleyball THON Chair, Fall 2012-Spring 2013

- JumpStart!
  Program Peer Leader, Summer 2010, 2011, and 2012