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Efficacy of Prophylactic Ankle Support upon Ankle Stabilization and Ground Reaction Forces in Female Volleyball Athletes

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May 2011
Abstract

The most common injury sustained while playing the sport of volleyball involves the ankle. Many preventative methods have been investigated, including the use of prophylactic ankle support. This study recruited 31 female volleyball athletes ages 14-25, who had actively participated in a competitive volleyball league within the last six months. Participants were randomly assigned to begin one of two trials in a brace or no brace presentation group. Reflective markers were placed on several anatomical landmarks. Participants were asked to jump laterally 10 times over a one-inch barrier while landing onto a force plate. A four-camera Qualisys 3-D motion capture system collected motion data at 240 hertz while the force plate collected data at 960 hertz. Results indicated that ankle bracing did not affect the range of motion of the ankle in the XZ plane (p>0.05), the YZ plane (p>0.05), or the XY plane (p>0.05). The force, however, generated when landing was significantly higher (p<0.05) in the no brace trial than when compared to the brace trial. In conclusion, occupational therapy could play a vital role in not only introducing people to sport and exercise or rehabilitating the athlete back to play, but using preventative methods to keep athletes safe including the advisement of ankle brace splints.
Introduction

The most common injury sustained while playing the sport of volleyball involves the ankle (Stasinopoulos, 2003). Cordova (2002) found that the majority of injuries sustained while participating in athletics are ankle sprains, which most commonly occur during rapidly changing the direction of movement. Even though the sport of volleyball is considered a “non-contact” sport, a large majority of the game requires the athletes to be in close proximity of the opposing team. Incidentally, most ankle sprains are a result of net play, where the opposing players are simultaneously pursuing the ball at each side of the net. Therefore, many injuries are a result of one or both players (blocker and attacker) landing incorrectly or on the opponents foot and rolling (i.e., inversion or eversion) the ankle (Stasinopoulos, 2003). As a result, many athletes are either required or choose to prophylactically wear external ankle support before or after sustaining an injury. The common injuries involved and the methods of prevention within the sport of volleyball can be more readily understood with knowledge of the regulations of the sport.

The Olympic sport of volleyball continues to develop since its creation in a YMCA gymnasium of Holyoke, Massachusetts, where William G. Morgan invented the sport back in 1895. Slight adjustments in the rules of volleyball are constantly evolving, but the main concepts remain the same. An official indoor volleyball court is 18 meters long by 8 meters wide, with a net dividing the two courts into equal halves. The net is 1 meter wide and 2.24 meters (7 feet 4 inches) in height for females (“Volleyball-Rules,” 2009). There are 6 players on the court in volleyball and subsequently 6 different positions played. The team consists of hitters, passers, and setters who can collectively touch the ball three times on each side of the net. The desired pattern is a dig (pass made after a hard-driven ball), a set (an overhead pass using only the hands) and a spike (a
single hand/arm attacking shot). Teams can also try to block the opponent's spike as it crosses the net. If a blocker hits the net during an attack, the whistle is blown for a side-out (loss of rally). Otherwise, it has been deemed playable to touch the net during play. If a player attempts a block and the ball is kept in play, the block does not count as one of the 3 touches allowed. Only the three players at the net, (front row) excluding the setter if coming up to set from the back row, can jump to play the ball near the net. The backcourt players can only hit the ball over the net if they jump from behind the attack line (located approximately 3 meters from the net). Every player must rotate one position clockwise each time they win back service. A single point is scored each time a team wins a volley or a rally, therefore the scoring system is named rally scoring. The ball is served into play either underhand, overhead, or jump served. Each player gets only one chance to serve (depending on age level). The serve can touch the net and continue into the opponent's court. Prior to or after a serve, a set number of substitutions can be made during the game. The only player that does not require using a substitution to enter the game is the libero. This player wears a different colored uniform from the rest of the team and can play in backcourt for any player on the team. The libero cannot serve or rotate into the front-line positions. The winner of the match is determined by the team who wins 3 of the 5 sets played. The first 4 sets are played to 25 and the 5th set (if required) is played to 15. Teams must win by two points (“The Game,” 2010).

Currently, the National Collegiate Athletic Association (NCAA) does not require athletes to wear external ankle support. According to a representative from Active Ankles, an official sponsor of the Olympic volleyball team, although not mandated, it is strongly encouraged by coaches and trainers to wear support (L. Blakemore, personal
communication March 17, 2010). It is up to the organization or the coach whether or not to require ankle support. At the college and professional level, most athletes make the choice themselves whether or not to wear them. However, several junior volleyball programs in the Midwestern portion of the United States are now requiring female athletes to wear external ankle support with or without prior injury (J. Schramm, personal communication, February 11, 2010). In 2003, Stasinopoulos’ study of reducing the incidence of ankle sprains showed that by wearing orthoses, one can reduce the prevalence of ankle sprains in previously sprained ankles, but not in previously uninjured ankles. However, the director of a volleyball club from the Midwest stated that her decision was made about five years ago to necessitate wearing active ankles (J. Schramm, personal communication, February, 2010). When asked why the decision was made, she stated that it was for the safety of players that play in the front row because they are not only doing a lot of high impact jumping, but they are also doing this next to other players and also very close to players in front of them on the other side of the net (J. Schramm, personal communication, February, 2010). She also stated that the average amount of time a club volleyball athlete spends playing volleyball at her facility is 4 total hours per day. This could average up to 12 hours per weekend of this type of play and fatigue sets in quickly with female athletes that are not in a daily training program. These factors increased the level of injury with players and mainly ankle injuries due to jumping and landing with fatigue and sometimes unsafe situations at the net with opponents (J. Schramm, personal communication, February, 2010). Because of the risk of injury involved during times of fatigue, Bahr (1997) and Verhagen (2003) examined the correlation between the two variables.
Bahr (1997) examined 89 injuries that collectively came from 272 athletes during 51,588 hours of play, 45,837 hours of training and 5,751 hours spent during game play. The total injury incidence was 1.7+/− 0.2 per 1,000 hours of play, 1.5+/− 0.2 during training and 3.5+/− 0.8 during game play. It could be concluded from the study that the ankle was the most commonly injured region followed by the lower back, knee, shoulder, and fingers (Bahr, 1997). Verhagen, Van der Beek, Bouter, Bahr, and Van Mechelen (2003) attempted to identify the incidence of acute and overuse volleyball injuries. The subjects used in the study were athletes from the second and third Dutch national volleyball divisions. After following the team for one season, there were a reported one hundred injuries. Ankle sprains accounted for the majority of the acute injuries (Verhagen et al. (2003). With volleyball injuries being the fourth most source of sports injuries (Stasinopoulos, 2003), external ankle support has become a widely used preventative strategy throughout sport organizations.

Although requiring athletes to wear external ankle support is currently up to the facility’s owner, at one Midwest volleyball club injuries have decreased by almost 50% after requiring ankle support. Interestingly, the owner of the club attributes this to the safety precautions taken at practice by everyone and also mental confidence knowing they have them on. Cordova (1998) investigated this idea by testing ground reaction forces and EMG activity with ankle bracing. The subjects performed several trials of a lateral dynamic movement at approximately 10%-20% less than what they perceived as their maximal speed. Before beginning the trials, the subjects were grouped into three ankle brace conditions (no brace-control, Aircast Sport-Stirrup, Active Ankle). The lateral movement used in the study required subjects to make a quick direction change
while accelerating from an established starting point to land onto the force platform and then change directions again back to the original starting position. The results of the study were that ankle bracing did not affect peak impact force, maximum loading force, or peak propulsion force in the lateral direction compared with the control condition. Furthermore, Cordova found that ankle bracing reduced the EMG activity of the peroneus longus when compared with the control condition (Cordova, 1998). Because of the frequency of ankle injuries, an extensive amount of research has been conducted to examine the external factors involved with injury. However, there continues to be a need for research in the area of internal factors that could impact play during the participation of sport.

When considering the above studies, it may seem peculiar why so many athletes put themselves at such risk of injury. An argument can be made that the engagement of sport can be a tremendously rewarding occupation. In fact, many studies in occupational therapy’s literature have investigated the differences in performance when subjects are given an occupationally embedded exercise versus rote exercise. However, the rote exercise used typically involves physical exercise. In many cases, the subjects involved in these studies are elderly patients of a skilled nursing facility (Haase, 1995; Lang, 1992; Yoder, 1989; Zimmerer-Branum, 1995). It is assumed in these studies the elderly participants find greater meaning in the occupationally embedded alternative over exercise. This assumption may or may not be true with a younger cohort of participants. More research needs to be conducted on physically active, young adults, who currently are participating in sport or have a recent history of participation.

It is the supposition of this study that to many, exercise is in fact, occupationally
embedded. Exercise, or sport, in general gives many people their meaning and provides a sense of purpose in their life. Sport and exercise can offer individuals both intrinsic and extrinsic motivation. Athletes all around the world are willing to put themselves in risk of injury to participate in the sport they love. Not only are they willing to do that, millions of dollars are spent by fans on sports each year. In 2006, a 30-second advertisement during the Super Bowl game cost $2.5 million. The top five Super Bowl advertisers alone accounted for $659 million in advertising over the past 20 years (Watershed Publishing, 2010).

Sport has arguably provided people meaning and purpose since the beginning of human existence. What we currently call sports was an important part of ancient society. Although the games were much more brutal and violent then, civilizations still came together as participators and spectators during the events. When the Olympics first began, they were held in Ancient Greece as part of religious rituals. The first known records of the Olympics date back to 776 B.C., when the games were held for one day and were always held in the same location (SapereCom, 2010). Although the rules and regulations have changed tremendously over the decades, the spirit that drives the passion for sport will, arguably continue to be in existence.

Similarly, in 1996, Nelson lectured on why the profession of occupational therapy will flourish in the 21st century (Nelson, 1996). He made the statement, “Real human beings needed therapeutic occupation in the days of Eleanor Clarke Slagle (1871-1942); they need therapeutic occupation in our times; and they will continue to need it beyond our days.” He went on to say, “The human being can attain enhanced health and quality of life by actively doing things that are personally meaningful and purposeful, in other
words, through occupation” (Nelson, 1996). Here we have two domains that arguably can be in existence forever, sport and human occupation. Why then, is sport such an untapped realm of occupational therapy? Traditionally, other professions have focused on sport. Many people choose to have careers in sports, such as coaching, athletic training, reporting, managing, participating, or caring for athletes. Occupational therapy continues to have an unfulfilled role with one of the oldest and most continuous meaningful occupation to date, sport. As a profession that is tuned to each individual’s preferences, sport is a legitimate domain to expand the profession. Occupational therapy could play a vital role in not only introducing people to sport and exercise, but using preventative methods to keep athletes safe. A unique role of the occupational therapist is the ability to fabricate splints/orthoses for the upper and lower extremities. Therefore, there is a need in the field for more understanding of the common orthoses used in sport, which are becoming increasingly common to be required while participating. In addition to the need for more research on sport and occupational therapy, there is a need for more research on occupational therapy’s role in employing common injury preventative methods used for athletes.

While not in occupational therapy literature, Stasinopoulos (2003) studied the effectiveness of three different prophylactic interventions on preventing ankle injury. The participants in the study were female volleyball athletes who had a previous ankle injury during a single season. The participants were separated into three prophylactic intervention groups; technical training, proprioceptive training, and external support (orthosis). All three intervention methods were successful in improving prevention of further ankle sprain. The intervention that resulted in the most positive results was the
technical training group. In addition, the orthosis group (external support group) was found to be an ineffective method of intervention for athletes who had suffered multiple ankle sprains during their athletic careers (Stasinopoulos, 2003).

In addition to the incidence of injury and the methods of prevention, it is important for occupational therapists to know and understand the common risk factors involved in sport. Thacker (2010) conducted a systematic review of multiple studies that reported the risk of ankle sprains in sports. In addition to looking at the risk of ankle sprain, factors such as external support methods and the effect they have on performance were also included in the review. The results of the study were similar to Stasinopoulos in that the highest risk factor for ankle sprain is history of a previous sprain, which assumingly would make wearing an orthosis the most problematic for this group. In addition, Junge et al. (2006) examined the variability of injuries in different types of sports during the 2004 Olympic Games. A total of 377 injuries were reported from 456 matches. The results demonstrated half of all injuries affected the lower extremity followed by injuries of the head or neck. The upper extremities and the trunk were among the least common areas of injury. Of all the injuries reported, the most frequently injured body part was the head, followed by the ankle, and the knee. Junge et al. also examined the type of injury sustained with fractures and ligament ruptures having the highest rate of diagnosis. Less frequent diagnoses were dislocations, concussions and lesions of the meniscus (Junge et al, 2006).

The purpose of this study is to investigate the efficacy of wearing prophylactic ankle support, its ability to limit range of motion at the ankle joints, and its effects on ground reaction forces during a side jumping task. The research question is; does wearing
external ankle support give the participant a sense of security during jumping tasks, therefore increasing the ground reaction force? The research hypothesis is that the use of external ankle support with a healthy ankle will decrease the ROM at the ankle and increase the ground reaction force compared to when no ankle support is worn.

Methods

Participants

The study recruited 31 female volleyball athletes who had actively participated in a competitive volleyball league within the last six months. This proposed sample size was based on an alpha set at .05, a beta set at .8 with the assumption that the standard deviation between the two conditions would be 15 and the mean difference between the two conditions would be 5.10 degrees, therefore, an \( n = 31 \) provided adequate statistical power to avoid a Type II error. Inclusion criteria consisted of requiring the ownership of prophylactic ankle braces in addition to the proper athletic volleyball attire (spandex shorts, athletic shirts as well as athletic footwear). Participants who reported current symptoms of pain or have injured either ankle within the previous six weeks were excluded from the study. Those who have ever sustained an ankle sprain of a grade two or three (Wexler, 1998) were also excluded.

Participants were recruited via e-mail, flyers, and through word-of-mouth methods. Several club volleyball programs as well as high school volleyball programs from the Midwest were solicited to participate.

Apparatus

A four-camera Qualisys 3-D motion capture system collected motion data at 240 hertz. Force plate data was collected at 960 hertz. Data were collected in a motion lab located at The
University of Toledo, Ohio over the course of several months and stored on a computer hard drive for offline analysis. A Philips computer camera recorded the video data.

Procedure

This study was approved by the Biomedical Institutional Review Board and informed consent from all participants and parental approval by participants under the age of 18 was obtained prior to data collection. Participants were randomly assigned to one of two order of presentation groups (i.e. brace versus no brace) by a permuted block design using customized random number generator software. Reflective markers were placed at the following anatomical landmarks on both lower extremities: (a) sternum, (b) anterior iliac spine of the pelvis, (c) greater trochanter, (d) tibias anterior, (e) lateral condyle of femur, (f) lateral malleolous, (g) head of the first metatarsal, (h) talus (top of the foot), and (i) the head of the fifth metatarsal.

The participants were asked to stand on the left side of a barrier on a force plate. The 1 inch tall barrier divided the force plate into two equal halves. The participants stood with their feet together and their upper extremities across the chest to avoid interfering with the markers as much as possible. They were then asked to jump laterally over the barrier and back to their original position for a total of ten times. After completing one trial of ten lateral dynamic jumps, the participant was given a two minute rest before entering into the second condition (i.e. brace or no brace).

Dependent Variables and Statistical Analysis

A counter balance repeated measures research design was used. Data collection and statistical analysis for the motion capture data determined the range of motion (ROM) of the ankle, specifically, the difference between the maximum angle and the minimum angle for the
ankle and for supination/pronation were calculated. Peak resultant force was derived from the force plate data.

The data were then smoothed using a Butterworth filter with a cut-off frequency of 10 hertz. An exception was allotted for kinematic data that were used to calculate angle data in the XY plane, which were smoothed using a 15-point window moving average. Data were then statistically analyzed using Graphpad Prism for Windows version 4.02. A paired $t$-test and a Wilcoxon signed rank test were used to analyze the difference between the two conditions (i.e., brace versus no brace).

For the angle data, we investigated angles according to XZ and YZ planes because the actual plane for each representative angle for ankle flexion was not parallel with the XZ or the YZ planes. Therefore, we cannot say with certainty that ankle flexion is associated with the XZ plane and that the inversion/eversion is associated with the YZ plane. However, we still analyzed the ankle range of motion according to the XZ and YZ planes from the analysis package of Qualisys Track Manager.

We also examined the XY plane, which is associated with pronation/supination motions of the lower extremity. However, an accurate representation of pronation/supination requires angle calculations of the foot position relative to proximal landmarks that are disassociated with the lower extremity. This is because if the whole body turns direction while keeping in neutral (pronation/supination), the foot position with respect to the YZ plane would change, even with relatively little pronation/supination occurring. Therefore, trigonometry was used to calculate the position of the foot (using the ankle and talus markers to form a line with respect to the line traveling through the left and right ASIS). The formula for calculating pronation using the lines stated above is:
Tan\(\phi\)=tan (\(\alpha_2-\alpha_1\))

When calculating the angle data involving the Z axis (XZ and YZ), the lateral condyle, talus, and lateral malleolous markers were used. Data were interpolated (interpolation parameters used a maximum frame gap of ten sample). Each trial was analyzed for gaps in the data, those trials that had contiguous data involving two side jumps (a lateral jump over the barrier and back) were included in the data analysis.

For the angle data for the XZ plane were not skewed, therefore a one-tailed \(t\)-test was used to analyze that data, however, the data for the YZ and the XY planes were skewed, therefore a one-tailed Wilcoxon signed rank test was used for each of these analyses (see Table 1 & 2). For the force data, the maximum force of the X, Y, Z planes and the resolution were analyzed using a paired one-tailed \(t\)-test. Data were not skewed; therefore parametric statistical analyses were performed (see Tables 3 & 4).

Results

Raw data were collected from 31 participants for both force plate data and kinematic data. Thirteen of the 31 participants recruited were analyzed using a repeated measures design for the angle data. For the force data, the last 10 participants were dropped because the computer malfunctioned. Participants were therefore dropped for the angle data or force data because of computer or user errors. Participants in the study used a variety of ankle braces, which included: Mueller, ASO and Active Ankles.

Ankle bracing did not affect the ROM of the ankle in the XZ plane \((p>0.05)\), the YZ plane \((p>0.05)\), or the XY plane \((p>0.05)\) (see Table 1). See Table 2 for the descriptive data for the angles in the three planes. The force, however, generated when landing was significantly
higher ($p<0.05$) in the no brace trial than when compared to the brace trial, however, this was in the opposite direction than what was stated in the hypothesis (see Table 3). The descriptive force data can be found in Table 4. Therefore, the research hypothesis of the use of external ankle support decreasing the ROM and increasing the ground reaction forces is rejected.

**Discussion**

The purpose of the study was to explore the application of sport and the common orthotics used in sport to occupational therapy by investigating the efficacy of wearing prophylactic ankle support, the ability to limit range of motion at the ankle joints, and the effects on ground reaction forces. In doing so, this study investigated an area of practice not commonly associated with occupational therapy; namely, the realm of sport rehabilitation. As part of the Centennial Vision, scholars in occupational therapy have begun to revive the focus on occupation as the heart of occupational therapy. Therapists use the term occupation to embrace one’s individuality and free will when choosing meaningful daily tasks. Therefore, when the meaningful task that is freely chosen is physical exercise, it is this study’s opinion that the task becomes occupationally embedded and therefore should be of greater emphasis within occupational therapy practice.

The research question was; “Does wearing external ankle support give the participant a sense of security during jumping tasks, therefore increasing the ground reaction force?” The research hypothesis was that the use of external ankle support with a healthy ankle would decrease the ROM at the ankle and increase the ground reaction force compared to when no ankle support is worn.

The results showed that wearing prophylactic ankle braces did not affect the ROM of the ankle in the XZ plane, the YZ plane, or the XY plane. However, the force generated when
landing was significantly higher in the no brace trial then when compared to the brace trial. Therefore, the research hypothesis of the use of external ankle support decreasing the ROM and increasing the ground reaction forces was rejected.

The results also showed that the force generated when landing was significantly higher in the no brace condition, which is in opposition to the hypothesis of the study. It was the supposition that athletes would find a greater sense of security when wearing the ankle braces, therefore resulting in the athletes landing with greater force while wearing the braces. However, it can be presumed that the athletes felt more comfortable without the braces on. This could be because not all athletes who participated in the study currently wore ankle braces while competing in their regular season. It was required that the participants owned ankle braces, but it was not required that they actually had experience using them. For instance, some subjects reported to the investigator that participating in this study was the first time they had worn their ankle braces. Many of the participant’s legal guardians were interested in their child participating in the study in hopes that they would find whether or not it was indicated for them to wear the ankle braces. So for some, this study had personal meaning, in that the athletes were interested in finding out how they performed and what their level of comfort was wearing the braces versus not wearing the braces.

It is also a postulation that the tactile input from the braces cued the individual to land more softly after jumping. For those who were not used to having the ankle braces on, fear of falling or not performing as well could be experienced. Consequently, having a somewhat foreign object on the body could pose as a reminder to be more careful to avoid injury. Even if the athlete had no past injuries, it is possible that merely having the braces on could cue them to use safer mobility. This notion of practicing safer mobility while wearing the ankle braces
opposes this study’s hypothesis, which was that athletes would use safer mobility without the braces on in order to avoid injury.

These results differ from Cordova (1998), who investigated the ground reaction forces and EMG activity with ankle bracing while subjects performed lateral mobility. The three ankle brace conditions (no brace-control, Aircast Sport-Stirrup, Active Ankle) did not effect peak impact force, maximum loading force, or peak propulsion force in the lateral direction compared with the control condition. In the current study, ankle bracing did effect peak impact force in that the maximum landing force generated was greater when participants were not wearing the ankle braces.

Similar to the findings in this current study, Stasinopoulos’ (2003), found that the use of ankle orthoses were not effective in preventing muscle sprains. Stasinopoulos’ (2003) examined the effectiveness of three different prophylactic interventions on preventing ankle injury. Results showed that all three intervention methods were successful in improving prevention of further ankle sprain. More interestingly, the orthosis group was found to be an ineffective method of intervention for athletes who had suffered multiple ankle sprains. If this result were compared with the results of the current study, it would be the supposition that athletes with multiple injuries would be landing with less force when wearing the ankle brace, resulting in decreased muscle strength overtime. This is an area that needs further research to determine whether wearing ankle braces over long periods of time would in fact decrease muscle strength and increase the risk of reoccurring injury.

The literature on the risk of ankle injury in sport (more specifically, volleyball) shows profound evidence toward high risk. Stasinopoulos (2003) even found that the most common injury sustained while playing volleyball involves the ankle. Similarly, Cordova (2002) found
that the majority of injuries occur during rapidly changing the direction of movement. Much of the risk involved comes from fatigue. Verhagen et al. (2003) followed a Dutch national volleyball division for one year and reported one hundred injuries, in which ankle injuries accounted for the majority. Overall, it is evident that the risk of ankle injury in volleyball athletes is high. While it was not the purpose of this study to continue to investigate the risk level associated with playing volleyball, this study purported to investigate what the influence of wearing ankle braces would be on available ROM and ground reaction forces, using participants with no history of ankle injury.

In summary, the results of the current study differ from Cordova (1998) in that wearing the ankle braces did affect the maximum force generated while performing a lateral jumping task. Although the current study did not investigate the use of ankle braces as an intervention method after injury, the results of the current study can be applied to Stasinopoulos (2003) by assuming athletes with multiple ankle injuries would generate less force while using ankle braces. It was also the findings of the study (J. Schramm, personal communication, February 11, 2010) that it was mandated that many volleyball athletes were to wear ankle braces, regardless of whether the athlete had been previously injured. Similar to Cordova (2002) and Verhagen et al. (2003), the Midwest volleyball club included in this study believes wearing ankle braces during times of fatigue will reduce the risk of injury. The results of this study showed ankle bracing was a non-effective way of reducing the ROM at the ankle, which could result in reducing the risk of several types of ankle sprains (i.e. inversion/eversion ankle sprains). However, participants did land significantly softer when wearing the ankle braces. This raises the question as to whether or not landing with more force over a long period of time strengthens the muscles around the ankle,
therefore preventing injury, or if landing with more force increases the risk of ankle injury during the present movement.

*Applications to Occupational Therapy*

An assumption of this study is that the engagement of sport can be a tremendously rewarding occupation for some individuals. To many, sport and exercise is an occupation of daily living. To some, sport is even a career and a ‘way of life.’ Occupational therapists who are interested in this field of study could engage in advocacy efforts to help educate others on the possibilities of sport and occupational therapy. In order for occupational therapist to get more involved in sport rehabilitation and the common orthoses used in sport, they need to be educated on sport specific protocol, such as the protocol for when it is indicated to suggest wearing ankle braces. If a sport rehabilitation course were not available, more emphasis could be placed on therapeutic exercise and human movement that could be applied to sport. In addition to course content, the option for completing a sport specific clinical rotation would be of great help to the occupational therapy student interested in sport. While attending school, or while practicing in the clinic, certifications are available for occupational therapist to earn, such as the Certified Strength and Conditioning Specialist certification (CSCS). Having this certification, would further qualify an occupational therapist for working with athletes, exercise modalities, and for the use of prophylactic bracing.

As previously mentioned, occupational therapy could play a vital role in not only introducing people to sport and exercise or rehabilitating the athlete back to play, but using preventative methods to keep athletes safe. A unique role of the occupational therapist is the ability to fabricate and recommend splints/orthoses for the upper and lower extremities. Therefore, there is a need in the field for more understanding of the common orthoses used in
sport, such as the ones investigated in the current study (i.e., Mueller, ASO and Active Ankles). Occupational therapists should also familiarize themselves with the literature cited in the current study, as well as similar literature outside the field and the results of the current study to enhance their understanding of the current trends in sport intervention and prevention, as well as the possible pros and cons of using prophylactic ankle support for female volleyball athletes.

Occupational therapists can use the results of this study when working with teenage volleyball players. In particular, when recommending the use of ankle braces, the occupational therapist can inform the volleyball player that the range of motion differences between having the brace on or off will not change much, but it is possible that their ground reaction forces may be lower when wearing the ankle brace. However, it is important for the occupational therapist to realize this is only one study in a line of studies and that in the end; the evidence is somewhat unequivocal as to the actual prophylactic benefit in regard to the prevention of ankle injury.

**Limitations**

Limitations to the study were that participants wore a variety of ankle braces, which were made of various different materials making it possible for them to have different durability levels. The sample size was also small, this was mostly because data collected occurred during the volleyball season, and was limited to one location.

Additionally, the planes of motion investigated for the angle data were not parallel with actual flexion/extension, pronation/supination, and internal/external rotation of the ankle joint. Therefore, we were unable to prove that the planes investigated in Qualysis Track Manager were associated with these movements of the ankle. Also, an accurate representation of pronation/supination requires angle calculations of the foot position relative to proximal landmarks that were not included in the angle analyses. Consequently, several of the markers
placed on the lower extremities were not used when calculating the angles because of either computer or user error. For a more detailed examination of the ROM at each ankle joint, the use of more motion capture cameras is suggested.

Conclusion

In this study, ankle bracing did not effect the ROM of the ankle. However, ankle bracing did effect the force generated when landing. Perhaps wearing the ankle braces provided haptic and tactile input that influenced the perception of how ‘hard’ the athlete landed thereby cuing a softer landing. Having an increased knowledge of the effects of ankle bracing on mobility is a large domain in which occupational therapist could expand the scope of practice upon. Therefore, more focus on sport education and more advocacy efforts are needed in the area of occupational therapy and sport.

Further research is needed in the area of long-term use of prophylactic ankle bracing and the longitudinal effects with no past injury history versus those with past ankle injury. Additionally, more research should be completed on the effects of occupationally embedded exercise versus rote exercise utilizing participants who are currently, or who were actively involved in sport prior to injury. Also, more literature should be created on what constitutes occupationally embedded exercise versus rote exercise. Is rote exercise solely physical exercise? It would be of interest to investigate in what instances does rote exercise become occupationally embedded? Is it when the individual freely chooses the exercise? Is it when the individual has personal goals related to increased physical strength and/or endurance (i.e. finishing a marathon)? Or is it when the rote exercise involves specific movement patterns related to function (i.e., an individual’s job involves a lot of sitting/standing, therefore they work-out the muscles specific to those movements)?
The current study needs to be replicated and should include volleyball athletes who had sustained injury to the ankle prior to participation. It would also be indicated to set the inclusion criteria to only athletes who actively use ankle braces. In the current study, both athletes who were and who were not required to wear ankle support were included in the data collection.

In conclusion, occupational therapy, along with sport, is a growing profession that is expected to continue to flourish in the 21st Century. It is the hope of this author through the use of this study to illustrate a few of the common threads between sport and occupational therapy. Specifically how occupational therapist’s expertise could enhance sport rehabilitation and the safety of volleyball athletes, as well as to raise awareness of why occupational therapists could be a valuable addition to the world of sport and exercise.
References


Stasinopoulos, D. (2004). Comparison of three preventive methods in order to reduce the


Table 1
Results for the difference in maximum and minimum angles between conditions in XZ, YZ, and XY Planes.

<table>
<thead>
<tr>
<th>Planes</th>
<th>$t$</th>
<th>df</th>
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<td></td>
<td>sum of positive</td>
<td>Sum of negative</td>
<td>$W$</td>
</tr>
<tr>
<td>YZ</td>
<td>46.00</td>
<td>-45.00</td>
<td>1.000</td>
</tr>
<tr>
<td>XY</td>
<td>31.00</td>
<td>-60.00</td>
<td>-29.00</td>
</tr>
</tbody>
</table>
Table 2

Descriptive statistics for the XZ, YZ, and XY planes.

<table>
<thead>
<tr>
<th></th>
<th>No Brace (degrees) XZ</th>
<th>Brace (degrees) XZ</th>
<th>No Brace (degrees) YZ</th>
<th>Brace (degrees) YZ</th>
<th>No Brace (degrees) XY</th>
<th>Brace (degrees) XY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>109.5</td>
<td>109.4</td>
<td>100.8</td>
<td>98.49</td>
<td>14.54</td>
<td>8.130</td>
</tr>
<tr>
<td>Median</td>
<td>129.2</td>
<td>131.6</td>
<td>114.6</td>
<td>115.5</td>
<td>25.21</td>
<td>30.02</td>
</tr>
<tr>
<td>Maximum</td>
<td>166.6</td>
<td>167.5</td>
<td>135.8</td>
<td>156.9</td>
<td>67.47</td>
<td>88.52</td>
</tr>
<tr>
<td>Mean</td>
<td>135.7</td>
<td>133.7</td>
<td>115.7</td>
<td>117.3</td>
<td>29.60</td>
<td>35.90</td>
</tr>
<tr>
<td>Skewness</td>
<td>.5736</td>
<td>.5646</td>
<td>.6894</td>
<td>1.380</td>
<td>1.891</td>
<td>1.412</td>
</tr>
</tbody>
</table>
Table 3

$t$-test results for max force in X, Y, and X axes.

<table>
<thead>
<tr>
<th>Axis</th>
<th>$t$</th>
<th>$df$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>0.7359</td>
<td>19</td>
<td>0.2354</td>
</tr>
<tr>
<td>Y</td>
<td>2.385</td>
<td>19</td>
<td>0.0138</td>
</tr>
<tr>
<td>Z</td>
<td>1.998</td>
<td>19</td>
<td>0.0301</td>
</tr>
<tr>
<td>Resolution</td>
<td>2.014</td>
<td>19</td>
<td>0.0292</td>
</tr>
</tbody>
</table>
Table 4

Mean and Standard Deviation Ground Reaction Forces in the X, Y, and Z axes.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No Brace</td>
<td>175.63</td>
<td>6.35</td>
<td>202.77</td>
<td>15.50</td>
<td>660.47</td>
<td>0.32</td>
<td>705.34</td>
<td>5.41</td>
</tr>
<tr>
<td>Brace</td>
<td>177.16</td>
<td>6.55</td>
<td>210.57</td>
<td>19.77</td>
<td>661.00</td>
<td>0.62</td>
<td>708.68</td>
<td>9.13</td>
</tr>
</tbody>
</table>