Perpetua: The UAH Journal of Undergraduate Research

Volume 3 | Issue 1 Article 5

12-1-2018

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***Abstract* –** PURPOSE: To test the effects of ankle bracing (rigid and semi-rigid) on performance in collegiate volleyball players. METHODS: Thirteen female division II collegiate volleyball players (height = 179.95cm ± 3.42; weight = 72.26 ± 6.01kg) were randomly assigned to a bracing condition (rigid, semi-rigid, no brace) and completed 3 different performance assessment skills. The T2 Active Ankle brace (Akron, OH) was used for the rigid brace and an AS1 Pro lace-up (Akron, OH) was used as the semi-rigid brace. Each participant performed a lower body power test, straight line speed test, and lateral movement speed test on three separate occasions. Lower body power was measured using a vertical jump test. Straight line speed was measured using a 20-yard sprint. Lateral movement speed was measured using a four-corner agility drill. RESULTS: There was no significant difference ($p < .05$) between bracing condition for vertical jump height, straight-line speed, or lateral movement speed. CONCLUSIONS: Implementation of bracing (either rigid or semi-rigid) as a preventative measure does not significantly affect performance in collegiate volleyball athletes.

I. Introduction

Volleyball is a popular sport that is played amongst several colleges affiliated with the National Collegiate Athletic Association (NCAA). Volleyball can be characterized as a sport involving high rates of jumping, sprinting, and lateral movements. Ankle sprains tend to happen in high-risk sports that are known for contact, a high amount of jumping, or indoor activities (Rosenbaum et al., 2005). Unsurprisingly, ankle sprains are by far the highest occurring volleyball injury, comprising nearly 32% of reported volleyball injuries (Reitmayer, 2017). Bracing is a reliable treatment option for recent ankle injuries as well as for the prevention of additional injuries in athletes with possible instabilities during sport activities. It is common for volleyball athletes to wear ankle braces at all times while playing and practicing (Rosenbaum et al., 2005; Shaw, Gribble, & Frye, 2008).

There are numerous types of ankle braces with different levels of ankle support that are worn by players, such as rigid and semi-rigid braces. Ankle braces can have a large impact on athletic performance, making the choice of ankle support a critical decision (Hume & Gerrard, 1998). Due to the different physical demands and movements between different positional players on the court, more rigid braces are widely accepted as an injury prevention measure. This is especially true for those who are involved in more explosive jumping, while the semi-rigid braces are known to benefit the defensive players who primarily perform lateral movements and sprints during the game. Ankle braces protect the ankle by restricting ankle range of motion (ROM) in static and dynamic conditions as well as other mechanisms that are not yet fully understood (Papadopoulos, Nicolopoulos, Anderson, Curran, & Athanasopoulos, 2005). Restricted ankle ROM may negatively affect performance in running and jumping activities, but it seems to be dependent upon the type of support tested (Hume & Gerrard, 1998). Although ankle bracing can protect from athletic injury and impact athletic performance, it is not known whether braces have the potential to hinder certain abilities of a volleyball athlete (Shaw, Gribble, & Frye, 2008).

Due to the uncertainty of the effect on performance, testing should be done to evaluate how rigid and semi-rigid ankle braces can affect a volleyball athlete's skill related performance. This study included measurements of volleyball player's vertical jump, straight line sprint speed, and lateral movement speed on three separate occasions using three different bracing conditions. The athletes performed these tests wearing a rigid ankle brace, a semi-rigid ankle brace, and no brace at all. It was hypothesized that semi-rigid ankle braces would be superior to rigid ankle braces on the skill related measures amongst the NCAA Division II volleyball players.

II. Methodology

Participants

Members of a United States Division II NCAA women's volleyball team were recruited for the study during the off-season. The official roster was composed of thirteen athletes (eight outside hitters, one setter, two middle blockers, and two defensive specialists). The participants included three freshmen, 6 sophomores, and four junior level athletes (age = 20.1 ± 2.1 years, height = 179.95 ± 3.42 cm, weight = 72.26 ± 6.01 kgs). Inclusion criteria consisted of individuals who were healthy, free from lower body injury, and cleared by the training staff for full participation. Exclusion criteria included: failing to show up to one or more testing sessions or sustaining an injury during the study that would prevent full participation.

Instrumentation

Rigid Brace: T2 Active Ankle brace (Akron, OH) was used for all rigid ankle bracing conditions (see **Figure 1**).

Semi-rigid brace: AS1 Pro lace-up brace (Akron, OH) was used for semi-rigid bracing conditions (see **Figure 1**).

No-Brace Condition: No-brace condition was implemented by using no brace or tape on the athlete for this session.

Figure 1. *The rigid (T2 Active Ankle) and semi-rigid (AS1 Pro Lace-Up) braces worn for the skill-related performance tests.*

Lower Body Power

Lower body power was measured by vertical jump using the Just Jump Mat (Rhode Island, United States). The participant squatted at a 45-degree angle of knee flexion and attempted their maximum vertical jump. They were able to use their arms to aid in attaining maximal jump height. The participants completed two jumps and the higher of the two measurements was recorded in inches (Rosenbaum et al., 2005).

Straight line speed

Straight line speed was measured by the participants completing a timed 20-yard sprint. The participants started at cone 1 and sprinted as fast as they could through cone 2 which were 20 yards apart.

Lateral movement speed

Lateral movement speed was measured by the participant completing a timed four-corner agility drill (Bot, 1999). The drill consisted of four cones placed in a square formation with each cone 25 feet apart. The participant did a walkthrough of the drill before the actual test to allow for test comprehension. The participant sprinted along line 1 and rounded the cone, then shuffled along line 2, then rounded the cone and sprinted along line 3, then rounded the cone, and shuffled along line 4 (See **Figure 2**).

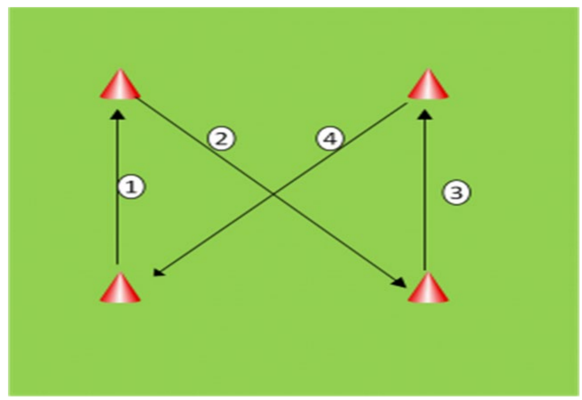

Figure 2. *Four corner agility drill for lateral movement speed*

Demographics

Participants reported class year and position (front row/back row).

Body mass and height

Height and body mass were measured using the Health-O-Meter digital scale (New Jersey, United States). Participants removed their shoes before taking the height and weight measurements.

Procedures

All participants were informed of the procedures of the study and signed an informed consent document prior to participation. Eligible participants reported to the testing gymnasium for all testing sessions. Upon arrival, participant's height and body mass were recorded. Following baseline characteristics, participants were randomly assigned to one of the three testing conditions: rigid brace (T2 Active Ankle, Akron, OH), semi-rigid lace-up brace (AS1 Pro, Akron, OH), and a no brace condition. The participants wore the same shoe model in their appropriate size throughout the entire testing period (Rosenbaum et al., 2005). The participants were randomly assigned to a bracing condition and an order of assessment drills. Participants then performed a 5-minute pre-determined warmup wearing the brace that was prescribed to them that session. The warmup consisted of a series of dynamic upper and lower body stretches led by the instructors. Lastly, the participant completed the assessment drills, which would then complete one session. This procedure was repeated on three separate occasions, for each testing condition.

Statistical Analyses

Statistical analyses were performed using the Statistical Package for Social Sciences version 24.0. A one-way analysis of variance was used to compare the values obtained while wearing either the rigid brace, semi-rigid brace, or the no brace condition. Statistical significance was established at $p < .05$.

III. Results

Participant Compliance and Exercise-Related Injuries

Compliance by the volleyball players for the research was 100%, with all participants completing the three required sessions. In addition, no exercise-related injuries were reported. Descriptive statistics are reported in **Table 1**.

Skill Related Performance Measures

The analysis indicated that lower body power was not different (see **Figure 3**) between bracing conditions, $F(2,38) = .858$, $p = .432$, there was no significant difference between the lower body skill related measures when compared across bracing condition. In regards to straight line speed, there was not a significant difference based upon bracing condition, $F(2,38) = 1.144$, $p = .330$. Furthermore, there was not a significant difference in lateral movement speed, $F(2,38) = .961$, $p = .392$, across the different bracing conditions. Averages for all conditions are reported in **Table 2**.

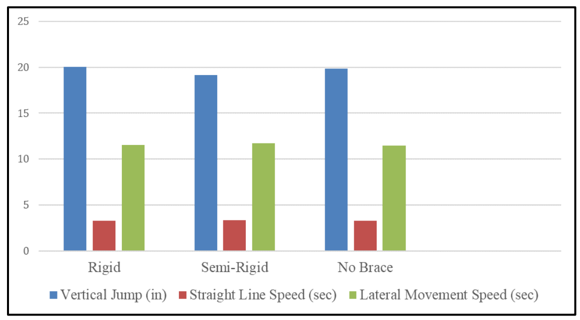

Figure 3. *Lower body performance test measurements*

Table 1. *Participant Characteristics*

Variable	M ± SD
Height (cm)	179.95 ± 3.42
Weight (kgs)	72.26 ± 6.01
Number of Freshmen	3
Number of Sophomores	6
Number of Juniors	4
Number of Outside Hitters	8
Number of Setters	1
Number of Middle Blocker	2
Number of Defensive Specialist	2

Note. Values are mean +/- standard deviations.

Table 2. *Conditioned Lower Body Skill Related Tests*

Condition	Vertical Jump (in)	Straight Line Speed (s)	Lateral Movement Speed (s)
Rigid	20.01 (1.67)	3.25 (.18)	11.55 (.34)
Semi-Rigid	19.15 (1.80)	3.33 (.18)	11.75 (.56)
No Brace	19.87 (1.64)	3.24 (.19)	11.49 (.42)

Note. Values are mean +/- standard deviation.

IV. Discussion

The focus of this study was to determine how various ankle bracing conditions affect lower body skill related measures in collegiate volleyball athletes. It was hypothesized that the semi-rigid bracing condition would result in optimal sports performance compared to the other conditions. Our findings indicate that the bracing conditions that were implemented had no significant impact on skill related performance.

Volleyball athletes use various ankle bracing conditions as a known preventative injury measure. Numerous clinical studies have been conducted regarding this correlation and found a reduction in ankle injuries with the use of ankle braces (Bot & Mechelen, 1999). Common ankle braces used in volleyball include varieties of both rigid and semi-rigid braces. The three conditions that the tests were performed under included a rigid brace, semi-rigid brace, and a no brace condition. The three performance measures that were tested were vertical jump height, straight-line speed, and lateral movement speed.

Vertical jump was measured due to the fact that it is a sport specific movement that translates into sport performance for volleyball athletes (Rosenbaum et al., 2005). The mean values for rigid, semi-rigid, and no brace vertical jump heights were respectively 20.01, 19.15, and 19.87 inches. The differences between the vertical jump heights were not significant. This supports the majority of previous research on the effects of ankle bracing on vertical jump height although previous research has been generally inconclusive. In a review article looking at 11 past studies, two showed negative effects of ankle bracing while the other nine showed no significant effect. The two studies were limited in that they only used one type of ankle brace (both semi-rigid braces), the 'Swede-O Universal' and 'Kallassy' brace (Bot & van Mechelen, 1999). While the results of this study strengthen the argument that bracing doesn't affect vertical height, this is not generalizable to all ankle braces, due to the variability in past research based on ankle brace brand.

Straight-line speed was measured by way of a 20-yard sprint under all three bracing conditions. A volleyball court measures 20 yards in length, which is why the 20-yard sprint test was implemented. This gave researchers a realistic measure of straight-line speed for volleyball athletes. The average straight-line sprint times for rigid, semi-rigid, and no brace conditions were respectively 3.25, 3.33, and 3.24 seconds. The difference between sprint times was not significant. This supports previous research, which encompasses a variety of sprint distances, on ankle stabilizers having no effects on sprints speed. Out of the same 11 studies, only one found an ankle brace (the Swede-O Universal) to have a negative effect on speed, but the article failed to disclose a detailed procedure, leaving the instruments, type of testing, and measurement accuracy unknown. Because other studies showed the same brand of brace as having no effect on sprint speed, the conclusion is still held that ankle-bracing has no significant effect on straight-line speed (Bot & van Mechelen, 1999). Ankle bracing should permit full dorsiflexion and plantar flexion, while only limiting inversion and eversion, therefore it is expected to have no effect on the body's ability to create maximum force during a sprint (Verbrugge, 1996). There was no significant difference in straight line speed during our test, supporting expectations that ankle bracing does not limit straight-line sprint speed.

Lateral movement speed was measured by a four-corner agility drill under all three conditions (See Figure 2). Volleyball athletes perform lateral movements constantly, as a part of game play for the sport. Using this test allows researchers to see a combination of different agility movements (Bot & Mechelen, 1999). Average time of completion in the lateral movement test for rigid, semi-rigid, and no brace conditions was respectively 11.55, 11.75, and 11.49 seconds. The difference between the three conditions was also not significant. Previous research found measuring agility drills under racing conditions was only inconclusive with regard to the 'Aircast Air-Stirrup' ankle brace. Other studies support that there is no significant difference in lateral movement speed as a result of ankle bracing (Bot & van Mechelen, 1999). Our research serves to support the findings of past literature with the implementation of a volleyball-specific agility test.

Limitations

This study was limited in that it included a smaller sample size and only female participants. In addition, it was unknown how much experience volleyball players had using different types of ankle braces. Volleyball players that are accommodated to using a specific type of ankle brace may be less affected compared to someone who has not played while wearing an ankle brace or that specific type of brace.

Future Research

Future research should be conducted with a wider subject base, potentially with male volleyball players. To expand knowledge about the consequences of prophylactic ankle-bracing, a longitudinal study could be implemented. A longitudinal study could also include groups with and without past experience using ankle braces to see whether accommodation to the ankle brace is necessary to avoid hindrance of performance. In addition, a longitudinal study could provide knowledge about how prophylactic use of ankle braces effects the strength of ankle muscles long-term. Ankle braces have been shown to decrease muscle activation in some functional exercises (Feger, Donovan, Hart, & Hertel, 2014). Therefore, more information is needed as to observe whether prophylactic ankle bracing would result in weakened muscles needed specifically for volleyball performance.

V. Conclusion

This research project featured NCAA Division II collegiate volleyball players using a variety of ankle braces and there were no complications that negatively affected the research process. Given the prevalence of ankle bracing being used in volleyball and other high risk sports, other research can be conducted using injury history of the individual athletes. The results from our study demonstrated that ankle braces do not impact sport related performance in volleyball players. While long-term effects of prophylactic ankle bracing are still unknown, the information provided by this study can assist coaches and trainers in their decision making. Coaches are constantly having to weigh the risks and benefits in decisions concerning their players. Having evidence-based information on both the benefits and the risks of ankle braces can help coaches have increased confidence that they are not compromising their player's immediate performance by implementing prophylactic ankle bracing. Given the availability of ankle braces that are easy to use and cost efficient, our findings support that the implementation of bracing as a preventative measure does not hinder sport performance in volleyball athletes.

VI. Acknowledgements

The authors would like to thank all the participants for their dedication and effort throughout the study.

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