EFFECTS OF ANKLE STABILIZATION ON PUSH-OFF MECHANICS FROM A THREE-POINT STANCE IN FOOTBALL

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The purpose of this investigation was to examine the effects of taping and bracing on push-off mechanics from a three-point football stance. Nineteen males were tested under three ankle stabilization conditions: braced, taped, and control. Participants performed five trials in each condition. Two 250Hz video cameras and a forceplate were used to collect data. A MANOVA with repeated measures revealed a significant main effect for condition. Post hoc analysis indicated that bracing and taping resulted in reduced minimum and maximum ankle angles and maximum angular velocity compared to the control. The horizontal velocity of the center of mass at takeofffor the tape condition was significantly lower than the control. Bracing and taping can have a negative effect on push-off mechanics.

KEY WORDS: ankle brace; ankle stabilization; sport stirrup; modified Gibney technique.

INTRODUCTION: It has been reported that up to 45% of all musculoskeletal sports injuries occur at the ankle joint (Robbins, Waked, & Rappel, 1995). Regardless of the age or skill level of the athletes, the single most common injury is the ankle sprain. Ankle sprains result in a considerable amount of lost practice and competitive playing time. Specifically, almost 85% of all ankle injuries involve damage to the lateral ankle ligaments (Gross et al., 1994). These ligamentous structures are most susceptible to a sprain during forced plantar flexion and inversion of the foot exceeding the normal range of motion (ROM). The running, planting, and cutting movements in football combined with the above average size of football players (e.g. linemen) make football an injury prone sport. According to Macpherson, Sitler, Kimura, and Horodyski (1995) 16% of high school football injuries involve the ankle.

Prophylactic taping has long been used as a means of protection against ankle injury in football and many other sports. Hume (1998) concluded in his review that taping provides stabilizing properties to the ankle through increased muscle activation. In addition, ankle stabilization protects against ankle injury due to improved proprioception has also been suggested (Robbins et al., 1995). While prophylactic taping seems to be a viable and easy answer to prevent ankle injuries, it has several potentially negative attributes. For many athletic programs the cost of materials, time for taping, and the need for specially trained personnel to apply tape makes taping a financial burden. For example, It is estimated that at the University of Utah spends at least $16,000 per year to provide tape for the football team (Coffman & Mitze, 1989). Statistics such as these have led sports administrators to seek alternatives that are not only cost effective and less time consuming but also provide equal or greater ankle stabilization and protection.

Currently there are two general types of prophylactic ankle stabilizers/braces available: semirigid and soft-shell. Because athletes can apply their own prophylactic ankle stabilizer, the use of prophylactic ankle stabilizers negate the extensive hours required by athletic trainers to tape athletes. Another benefit is the fact that braces are reusable and eliminate the financial burden of buying extreme amounts of athletic tape that is usually placed on the athletic department. While injury prevention is the most important criterion, possible limitations of functional/athletic performance are also a major concern. Few studies have focused on the effects of prophylactic ankle taping and bracing on athletic or motor performance and a very small percentage of these studies have involved football-related activities (Macpherson et al., 1995). Thus, the purpose of this study was to examine the effects of taping and bracing on ankle joint kinematics and power, and the horizontal velocity of the body center of mass (COM) at the instant of takeoff during a maximal effort push-off from a 3-point stance that is commonly used by football players. It was hypothesized that the prophylactic ankle stabilization would significantly decrease the ankle joint ROM and power, and the COM horizontal velocity attakeoff, and increase the push-off time as compared to the control.

METHODS: Nineteen male volunteers (age = 21.1 ± 1.7 yrs, height = 184.1 ± 7.9 cm, and mass = 91.9 ± 20.1 kg) participated in this study. All participants had at least three years of high school football experience and were familiar with the three-point football stance. They were healthy, physically active, and had no history of serious injury or surgery to the lower extremities. In addition, they had no incidence of ankle sprain within six months before the date of testing. All participants signed an informed consent agreement before participation.
Instrumentation. Two genlocked Kodak SR 500 (Kodak Eastman, Rochester, NY) high-speed video cameras operating at 250 Hz were used to capture the push-off action of the left leg. The cameras were located on the left side of the participant approximately 45° in front of and behind the frontal plane and about 4 m away from the forceplate used in this study. The ground reaction forces (GRFs) during push-off were recorded at 1000 Hz using a Bertec forceplate (Type 4060-10, Bertec Corporation, Columbus, OH). A custom-made signal generator unit, located 5 m in front of the participant, was used to present a start signal. An audible (a short beep) and visual (light flash) signal were emitted simultaneously from the signal generator when the unit was activated by a remote switch.
Ankle stabilization. The Modified Gibney Closed Basket Weave technique was used for the application of athletic tape (Coach Athletic Tape, Johnson & Johnson, Skillman, NJ). Pre wrap was applied to the ankle before the tape. The same certified athletic trainer performed taping on all the participants. The Sport Stirrup (Aircast Inc., Summit, NJ) was the representative semirigid prophylactic ankle stabilizer used in this study. The manufacturer's instructions regarding brace application were followed for each participant.
Protocol. All participants wore their own athletic shoes during the trials. Each participant was weighed and anthropometric measurements (foot width, foot length, malleolous width, malleolous height, knee diameter, shank length, calf circumference of the left leg) were taken using an anthropometer (Seritex Inc., New York, NY) or a flexible tape. After warming-up, reflective markers were placed on the lateral epicondyle of the femur, lateral malleolous, calcaneous, and head of the 2nd metatarsal (on the shoe) of the participant's left leg. An additional marker consisting of a base, a 5 cm long wand, and a spherical reflective marker, was attached to the lateral aspect of the mid-shank. This marker was positioned at the point of the greatest curvature of the shank and aligned with the lateral malleolus and lateral epicondyle when viewed from the left side. Each participant performed five trials under the three ankle stabilization conditions (control, tape, and brace). In each trial, the participant assumed a three-point stance with his left foot located at the center of the forceplate. Upon the synchronized audible and visual signals emitted from the signal generator located in front of the participant, the participant propelled himself forward as fast as possible. The active plantar flexion angles were measured before and after tape trials using a plastic goniometer.
Data Reduction. For each participant, the middle three trials for each condition were analyzed. A Peak Motus system was used to extract two-dimensional coordinates of different markers (automatic tracking) from the video recordings. A combination of GRF data, anthropometric measurements, and foot kinematics were used to calculate the resultant joint moments at the ankle. Applying the impulse-momentum relationship, the horizontal GRFs during the push-off (from movement initiation to takeoff) were used to determine the horizontal velocity of the subject's COM at the instant of takeoff.
Data Analysis. For the purpose of this study the push-off was separated into two phases. The loading phase started at initial movement and ended at the instant of minimum ankle angle and the push phase began at the end of the loading phase and ended at takeoff. The instant of takeoff was defined as the instant when the left foot left the forceplate. Seven dependentvariables were analyzed: maximum and minimum ankle joint angles during the push-off, maximum angular velocities of the ankle joint during the loading and push phases, maximum ankle joint power during the push-off, horizontal velocity of the COM at takeoff, and push-off time. All dependent variables were analyzed using a multivariate analysis of variance (MANOVA) with repeated measures. When a significant difference was found among the three ankle stabilization conditions, the Tukey HSD (Honestly Significant Difference) post hoc analysis was conducted. A t-test with repeated measures was used to determine whether there

was significant change in active plantar flexion angle before and after tape trials. A traditional level of significance (? = 0.05) was used for all comparisons.

RESULTS AND DISCUSSION: The MANOVA revealed significant differences among the different conditions ($F = 7.85$, $p < .001$). A significant difference was detected between the active plantar flexion angle recorded before and after tape condition trials. The t-test confirmed that the active plantar flexion angles after the tape condition trials (32.4±2.7°) were significantly greater than those before (30.7±2.7°) ($p<.001$).
A significant main effect for the condition was found for both the minimum ($p<.001$) and maximum ($p<.001$) ankle angles during the push-off. Post hoc analyses revealed that the minimum ankle angle for the control condition was significantly smaller and the maximum ankle angle for the control condition was significantly larger than the corresponding values for the tape or brace conditions (Table 1). These results support the hypothesis that the minimum and maximum angles of the ankle joint during the push-off would be significantly decreased by an application of tape or a brace. The negative effect of taping and bracing on ankle ROM impacts the stretch shortening cycle in the ankle extensor. The decrease in dorsiflexion limits the lengthening (eccentric contraction) and the decrease in plantar flexion affects the shortening (concentric contraction). These decreases in the maximum lengthening and shortening can disrupt the ability to produce a maximal push-off.

Table 1 Mean and SD for the different dependent measures for different test conditions.

	Brace		Tape		Control	
Measure	Mean	SD	Mean	SD	Mean	SD
Maximum Ankle Angle During the Push-off ( )*	94.6a	5.6	94.6b	6.7	98.5a, b	7.6
Minimum Ankle Angle During the Push-off ( )*	58.2a	5.4	57.6b	5.6	55.7a, b	5.0
Maximum Ankle Angular Velocity:						
Loading Phase (/s)	-63.6	21.2	-76.0	26.0	-67.8	33.0
Push Phase (/s)*	535.9a	67.0	567.5b	32.8	646.0a,b	99.6
Max Ankle Joint Power (W)	2482	1039	2526	970	2665	1207
Horizontal Velocity of COM at Takeoff (m/s)#	1.84	0.31	1.78b	0.26	1.88b	0.32
Time to Push-off (s)	0.49	0.08	0.51	0.12	0.52	0.11

Significant difference among different ankle stabilization conditions (*p < .01, #p < .05).
a Significant difference between control and brace conditions.
b Significant difference between control and tape conditions.

A significant main effect for condition was found for the maximum angular velocity during the push phase ($p<.001$). Post hoc analysis revealed that the maximum angular velocity during the push phase for the control condition was significantly larger than both the tape and brace conditions. No significant main effect for condition was found for the maximum angular velocity during the loading phase of the push-off ($p=.09$). These results partially support the hypothesis that taping and bracing would significantly decrease the maximum angular velocities of the ankle during the loading and push phases. While there was no difference among ankle stabilization conditions for the loading phase, there was a significant difference for the push phase. The significant decrease in maximum angular velocity during the push phase due to taping and bracing indicates that the shortening velocity of the plantar flexor is affected. The negative effect of bracing and taping during the push phase limits an athlete's ability to produce forceful plantar flexion.

No significant main effect for condition was found for the maximum ankle joint power during the push-off (p=.42). Joint power is a measure of explosiveness in joint movement. While the control condition produced a higher mean ankle power value (2752.7 W) than that of brace (2586.7 W) and tape (2597.6 W) the difference was not significant. When an ankle is taped or braced, it is impossible to determine the contribution of the tape and brace to the resultant ankle joint moments measured during the push-off. Any extra contribution could increase the maximum power output and falsify the findings.

A significant main effect for condition was found for the horizontal COM velocity at takeoff (p=.03). The horizontal velocity at takeoff was found to be significantly larger for the control condition than for the tape condition. No significant difference was found between the tape and brace conditions or the brace and control conditions. These results partially supported the hypothesis that the horizontal COM velocity at takeoff would be decreased by the application of tape or a brace. Wearing a stirrup brace did not significantly affect the ability to generate a horizontal velocity at takeoff. But the application of tape to the ankle joint negatively affected the horizontal velocity at takeoff when compared to the control condition. Thus, a football player's performance would not be affected by wearing this type of brace, but would still provide injury protection.

No significant main effect for condition was found for the push-off time (p=.24). This result does not support the hypothesis that the push-off time would be significantly increased by the application of tape or a brace. This could be due to the effects of ankle stabilization on ankle ROM and angular velocity during the push-off. Because the push-off time is calculated as the ROM divided by the average angular velocity, a larger ROM divided by a faster average angular velocity (control condition) would be similar to that of a smaller ROM divided by a slower average angular velocity (tape and brace conditions).

CONCLUSION: The overall effect of taping seems to be detrimental to the performance of push-off from a three-point stance. The brace condition exhibited a horizontal COM velocity at takeoff comparable to that of the control condition. When compared to taping, a stirrup type brace has less negative effects on performance while providing injury protection. The significant decrease in horizontal COM velocity at takeoff due to taping may suggest that trainers, physicians, and coaches should reconsider their practice of mandatory taping for all players unless the benefit in injury prevention outweighs the effect on performance. The use of prophylactic braces is an attractive alternative because of its effectiveness in injury prevention and the possibility of saving expenses associated with tapes and taping.

REFERENCES:

Coffman, J.L., & Mitze, N.L. (1989). A comparison of ankle taping and the aircast sport stirrup on athletic performance. Journal of Athletic Training, 24, 123-124.

Gross, M. T., Batten, A. M., Lamm, A. L., Lorren, J. L., Stevens, J. J., Davis, J. M., & Wilkerson, G. B. (1994). Comparison of Donjoy ankle ligament protector and subtalar sling ankle taping in restricting foot and ankle motion before and after exercise. Journal of Orthopaedic & Sports Physical Therapy, 1, 33-41.

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