Effectiveness of Novel Ankle Prophylactic Compared With Lace-Up Brace or Tape

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Context: Conventional ankle prophylactics restrict harmful ankle inversion motions that lead to injury. But these existing prophylactics also limit other ankle motions, potentially leading to detriments in functional joint capacity. The ankle roll guard (ARG) may alleviate the prevailing issues of existing ankle prophylactics and prevent harmful ankle inversion, while allowing other joint motions. **Objective:** This technical report sought to compare the ARG's ability to prevent ankle inversion, but not restrict other ankle motions with existing prophylactics. **Design:** Repeated-measures study. **Setting:** Motion capture laboratory. **Participants:** Thirty participants. **Intervention:** Each participant had dominant limb ankle kinematics recorded during 5 successful trials of a sudden inversion event and 30-cm drop landing task with each of 4 conditions (ARG, ASO ankle stabilizer [brace], closed-basket weave athletic tape [tape], and unbraced [control]). **Main Outcome Measures:** Peak ankle inversion angle, range of inversion motion (ROM), and time to peak inversion during the sudden inversion event, and ankle plantar- and dorsiflexion ROM during the drop landing were submitted to a 1-way repeated-measures analysis of variance to test the main effect of prophylaxis. **Results:** Participants exhibited greater inversion ROM with control compared with tape ($P = .001$), and greater plantar- and dorsiflexion ROM with ARG and control compared with brace ($P = .02$, $P = .001$) and tape ($P = .02$, $P < .001$). It took significantly longer to reach peak ankle inversion with brace and tape compared with ARG ($P < .001$, $P = .001$) and control ($P = .01$, $P = .01$). No significant difference in peak ankle inversion was observed between any condition ($P > .05$). **Conclusion:** The ARG may prevent ankle inversion angles where injury is thought to occur (reportedly $>41^\circ$), but is less restrictive than existing prophylactics. The less restrictive ARG may make its use ideal during rehabilitation as it allows ankle plantar- and dorsiflexion motions, while preventing inversion related to injury.

Keywords: ankle sprain, ankle inversion, musculoskeletal injury

Ankle sprain, the most common sport and recreational injury,¹ usually occurs from sudden joint inversion (ie, sole of the foot directed inward) greater than 30° .² To prevent these injuries, health practitioners and athletes use prophylactic products, such as a lace-up brace or athletic tape, to add mechanical joint stability. Typically, these prophylactic products seek to restrict ankle inversion, but not other joint motions (such as plantar- and dorsiflexion). Ankle prophylactic products are reportedly effective at reducing the frequency of injury by significantly altering static and dynamic ankle position, reducing maximum ankle inversion angle and velocity, and increasing the time to reach peak ankle inversion when compared with unbraced (control) ankles.³⁻⁵ However, the effectiveness of ankle prophylactics to prevent ankle injury and/or reinjury is reportedly dependent on specific device design.⁶

Two common ankle prophylactics include nonelastic athletic tape and lace-up brace. Nonelastic tape is typically applied in a closed-basket weave pattern around the ankle to provide mechanical stability. Lace-up braces generally provide stability with Velcro straps and/or laces, similar to a high top shoe, and/or rigid plastic supports attached to a nylon sheath covering the ankle. To reduce injury frequency, nonelastic tape and lace-up braces reportedly decrease peak ankle inversion and increase time to peak ankle inversion compared with an unbraced ankle up to 8° and 15%, respectively.^{5,6} Although both ankle prophylactics effectively reduce ankle inversion and subsequent injury, they reportedly restrict other ankle joint motions, including plantar- and dorsiflexion, during

sports-related tasks, like the drop landing. Ankle prophylactics reportedly decrease plantar- and dorsiflexion motions up to 11° during a drop landing.⁷ Restricting ankle motion may fail to address specific functional or mechanical postinjury impairments that predispose an individual to reinjury and joint instability.⁸

The ideal ankle prophylactic would not restrict other typical joint motions, rather only prevent the excessive ankle inversion thought to produce injury.¹ With that in mind, an innovative prophylactic product—ankle roll guard (ARG)—was recently patented and designed to alleviate the prevailing issues of existing ankle prophylactic products. The ARG's novel design supposedly prevents excessive ankle inversion with a lightweight buttress on the lateral aspect of the shoe, but allows the user to maintain "other" ankle motions. However, ARG currently lacks verifiable and independent scientific data on the effectiveness of their prophylactic product. This technical report sought to quantify and compare the ARG's effectiveness to prevent excessive ankle inversion, but not constrain "other" typical joint motions with existing prophylactic products (both nonelastic tape and lace-up brace).

Methods

Thirty (15 males and 15 females) participants (21.7 [2.9] y, 1.7 [0.1] m, and 72.5 [11.7] kg) had ankle kinematics quantified during a sudden inversion event (Figure 1) and drop landing task (Figure 2). For the sudden inversion, participants stood on a wooden platform that contained side-by-side trap doors. Then, a researcher removed the mechanical support of 1 trapdoor, allowing the door to be rotated 30° producing a sudden ankle inversion. For

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the drop landing task, participants stepped off a 30-cm plyometric box and landed on each foot simultaneously. Each participant performed both tasks with 4 conditions (ARG—Armor1, brace—Medspec ASO Ankle Stabilizer [Medical Specialties Inc, Charlotte, NC], tape—closed-basket weave athletic tape, and control—unbraced). Both the task and condition testing sequence were randomly assigned to each participant prior to beginning the study.

During testing, participants performed 5 successful trials for each task with every condition. During each trial, participants had dominant limb ankle biomechanics quantified from the 3D trajectories of 32 retroreflective skin markers. Marker trajectories were recorded with 8 high-speed (240 fps) optical cameras (Vicon, Oxford, United Kingdom). The recorded marker trajectories were filtered with low-pass fourth-order Butterworth filter at 12-Hz cutoff frequency and then processed to solve joint rotations in Visual 3D (v6.00; C-Motion, Rockville, MD) and expressed relative to participant's anatomical position. Ankle kinematics were time normalized from 0% to 100% of each event and resampled at 1% increments ($N = 101$). During the sudden inversion, event start was defined as the first instance ankle inversion exceeded 2 SDs above baseline (anatomical position), and event end was defined as peak ankle inversion plus 20 frames. During drop landing, event start was defined as initial contact (when ground reaction force first exceeds 10 N) and event end defined as weight acceptance (when ground reaction force stabilizes at body weight).

Ankle kinematics selected for statistical comparison included peak ankle inversion angle, range of inversion motion (ROM; peak angle–initial angle), time to peak ankle inversion for the sudden inversion, and range of plantar- and dorsiflexion motions for the drop landing. Each variable was submitted to a 1-way repeated-measures analysis of variance to test the effect of each condition (ARG, brace, control, and tape). A Bonferroni correction procedure was used for pairwise comparisons. All statistical analyses were performed using SPSS software (version 24.0; IBM, Armonk, NY) with alpha level at .05.

Results

There was a significant main effect of condition on inversion ROM ($P < .001$) and time to peak ankle inversion ($P < .001$), but not peak inversion angle ($P = .38$) during the sudden inversion (Table 1 and Figure 1); and a significant main effect of condition for plantar- and dorsiflexion ROM ($P < .001$) during the drop landing (Table 1 and Figure 2). Participants exhibited greater inversion ROM with control compared with tape ($P = .001$), as well as greater plantar- and dorsiflexion ROM with ARG and control compared with brace ($P = .02$, $P = .001$) and tape ($P = .02$, $P < .001$). It took significantly longer to reach peak ankle inversion with brace and tape compared with ARG ($P < .001$, $P = .001$) and control ($P = .01$, $P = .01$).

Figure 1 — Depicts the ankle roll guard (A), and the experimental setup for the sudden inversion event with the participant's ankle inverted (B) and drop landing (C).

Figure 2 — Depicts mean (SD) ankle inversion (A) and plantar- and dorsiflexion angles (B) recorded for each condition (ARG, brace, control, and tape) during the sudden inversion event and landing phase (0%–100%) of the drop landing task, respectively. ARG indicates ankle roll guard; ROM, range of inversion motion.

Table 1 Mean (SD) Ankle Kinematics Quantified During the Sudden Inversion and Drop Landing for Each Prophylactic (Ankle Roll Guard, Brace, Tape, and Control)

	Sudden inversion			Drop landing
	Peak ankle inversion, deg	Range of ankle inversion, deg	Time to peak inversion, s	Range of plantar flexion, deg
Ankle roll guard	35.1 (4.6)	26.1 (3.1)	0.19 (0.04)	49.5 (9.5)
Brace	34.7 (4.8)	24.9 (3.0)	0.24 (0.06)	44.7 (8.0)
Control	35.7 (5.4)	26.6 (4.1)	0.20 (0.04)	50.5 (8.2)
Tape	34.2 (5.3)	24.4 (4.2)	0.23 (0.04)	45.4 (6.9)

Discussion

The ARG may prevent excessive ankle inversion, but not as effectively as “more” restrictive brace and tape. During the sudden inversion, participants exhibited peak ankle inversion of 35.1°, 34.7°, and 34.2° with the ARG, brace, and tape, respectively. Each ankle prophylactic prevented peak ankle inversion from exceeding 36°, or 5° below where an injury occurred during a realistic sports maneuver.⁹ But, in contradiction with previous experimental evidence,^{3,4} no significant difference in peak inversion was observed between tested conditions, or between each prophylactic and the unbraced control. While the reason for the discrepancy is not immediately evident, the peak inversion angle currently exhibited during the control condition was 4° smaller than previously reported.⁴ Considering ankle prophylactics, including the brace and tape presently tested, effectively reduce the frequency of ankle injury, the small reductions in peak ankle inversion (~0.6° to 1.5°) during the sudden inversion event may be clinically significant. All tested ankle prophylactics, ARG included, may provide mechanical stability to prevent joint inversion that leads to ligament damage and injury at the ankle, but do not meet a priori standards for statistical significance. Further study is warranted to determine whether ARG

provides clinically significant reduction in peak ankle inversion compared with control or other ankle prophylactic design.

The ARG may limit harmful peak ankle inversion angles, yet may not provide the mechanical restriction of other prophylactics. During the sudden inversion, brace and tape provided 1.7° and 2.2° more restriction of ankle inversion ROM compared with control, whereas with the ARG, participants exhibited a nonsignificant increase of 1.2° and 1.7° in inversion ROM compared with the brace and tape. Furthermore, participants took significantly longer to reach the peak inversion with both brace (0.24 s) and tape (0.23 s) compared with ARG (0.19 s) during the sudden inversion. The increased restriction provided by the brace and tape may afford the user sufficient time to coordinate a neuromuscular response to effectively limit inversion motions and lengthen the time to reach peak ankle inversion, subsequently decreasing injury risk.¹⁰

Ideal ankle prophylactic design would not restrict typical joint motions, rather only prevent motions related to ligament damage and injury.¹ Each tested prophylactic prevented excessive ankle inversion thought to lead to injury, but only the ARG allowed typical plantar- and dorsiflexion motions, while restricting ankle inversion. During the drop landing, participants exhibited ~5° greater plantar- and dorsiflexion ROM with the ARG compared

with brace and tape; however, no difference was evident between ARG and control (approximately 50° of total plantar- and dorsiflexion motions with each condition). This restriction of ankle motion may fail to address specific functional or mechanical post-injury impairments, that is, altered reflexes, neuromuscular control, or muscular weakness, increasing likelihood of joint instability development.⁸ Therefore, individuals who suffer an ankle sprain may benefit from ARG use during rehabilitation. During rehabilitation from initial ankle sprain, ARG use may allow the user typical ankle plantar- and dorsiflexion motions to decrease likelihood of functional impairment of the joint and instability development, while providing the restraint necessary to prevent excessive ankle inversion and injury during the healing process.

In conclusion, the ARG may provide the mechanical restriction to prevent ankle inversion angles that lead to injury (reportedly greater than 41°).⁹ Yet the ARG is less restrictive than brace and tape, and did not exhibit similar reductions in inversion ROM and time to peak inversion as those prophylactics. The ARG was the only prophylactic to allow typical ankle plantar- and dorsiflexion motions, while restricting excessive ankle inversion. The ARG's design may provide restraint to prevent injury during the healing process, but its limited mechanical restriction may make its use ideal during rehabilitation from initial injury, rather than as an injury prevention device.

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