# Ankle Joint Strength, Total Work, and ROM: Comparison Between Prophylactic Devices

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*ABSTRACT: This study compares ankle joint strength (plantar flexion and dorsiflexion isokinetic), total work, and range of motion (ROM) values among four different types of ankle joint protective devices: a) Active Ankle, b) Aircast, c) Swede-O-Universal, and d) protective tape wrap. A control treatment (without a protective device) also was employed . The subjects were ten male volunteers, age 23.5 ± 3.7 yrs. The Cybex 340 isokinetic dynamometer system, using computer-aided programs as well as the Upper Body Exercise Table (UBXT), was employed to measure peak ankle plantar and dorsiflexion isokinetic strength, total work, and ROM at 30°, 120° and 180°. In addition, passive ROM was measured with a Zimmer goniometer. Statistical analyses (ANOVA and post hoc analyses) indicated a significant difference ($p < 0.05$) between and among treatments for plantar flexion peak isokinetic strength, total work, and ROM variables. The results of this study suggest that ankle joint prophylactic guards do limit force production, total work, and ROM. In addition, there was a difference among Active Ankle, Aircast, Swede-O-Universal, and protective tape ankle support devices regarding the magnitude of ankle strength production and ROM permitted.*

Do ankle support devices (orthotics or taping) decrease the probability of sprained ankles without significantly decreasing strength, range of motion (ROM), and performance levels? There is little doubt that some form of ankle support will aid in decreasing the probability of an ankle sprain (4, 5, 6,11,12). A major criticism of tape wraps and supportive devices, however, is that they decrease the ROM and strength of plantar flexion and dorsiflexion, thereby hindering performance (7, 9,10). There are few published studies concerning ankle protective devices. This study compares ankle joint plantar flexion and dorsiflexion isokinetic strength, fatigue, and ROM values among four different types of ankle joint protective devices.

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## METHODS

The subjects were ten male volunteer college students (age = 23.5 ± 3.7 yrs, ht = 5.83 + 0.16 ft, and wt = 171.8 ± 22.09 lbs). Four subjects wore a size 9 men's shoe and six wore a size 10 men's shoe. All subjects were apparently healthy and had no history of ankle sprain for at least five months prior to testing. University procedures for the protection of human subjects were followed.

A Cybex 340 isokinetic dynamometer system using computer-aided programs, as well as an Upper Body Exercise Testing Table (Cybex Division of Lumex, Inc., Ronkonkoma. NY), were employed to measure ankle plantar flexion and dorsiflexion isokinetic strength, total work, and active ROM. In addition, passive ROM was measured in degrees with a Zimmer goniometer. The experimental protocol required each subject to report for testing five times, at 48-hour intervals at approximately the same time of day. A computer program dictated the test protocol, although we or the subject could terminate the testing at any time.

The order that subjects were assigned an experimental condition was counterbalanced with a Latin squares design. In the order of testing, the supportive device or tape was applied to each subject's left ankle. All subjects wore new B.G. Pro athletic shoes during all tests.

The ankle taping was a conventional closed basketweave with three heel locks (1 1/2 inch Johnson & Johnson linen coach tape) applied by a certified athletic trainer over a spray adherent and underwrap (2).

Subjects jogged (6.0 mph) for approximately two minutes on a treadmill, then walked in a hallway at a freely chosen speed for approximately two minutes. They were then tested for plantar flexion and dorsiflexion isokinetic strength, total work, and ROM.

All testing took place with subjects in a prone position on the Upper Body Exercise Table (UBXT) with their knees extended and their left foot in the footplate attached to the dynamometer. The ankles were secured to the footplate using a plantar/dorsiflexion footplate belt and secured to the UBXT with a pelvic belt applied just above the knees.

The ankle axis of rotation passed obliquely through the tip of the lateral malleolus of the fibula and the trochlea of the talus, exiting just distal to the tip of the medial malleolus of the tibia. Stabilizing the foot on the footplate eliminated movement of the longitudinal arch, which if not controlled might falsely add to the range of motion measurements.

Strength was tested isokinetically at 30°/sec, at 120°/sec, and at 180°/sec, with 20 seconds rest between trials. Subjects were given four practice trials at each speed and were encouraged not to give an all-out effort until the third or fourth attempt. Subjects rested for 20 seconds, then were asked to perform three successive maximum voluntary contractions. A color computer monitor provided the subjects with video performance feedback throughout each trial.

After the three strength tests the subjects rested for 20 seconds, then practiced four contractions of the work performance tests at 180°. They then took the work performance test, which consisted of maximum voluntary plantar/dorsiflexion contractions.

Peak torque values were divided by body weight in order to normalize the data. Each dependent variable was evaluated with an analysis of variance (ANOVA) with repeated measures. Significant F values were further tested with Scheffe's *post hoc* analysis.

## RESULTS

The normalized peak torque values are presented in Table 1. There was a significant difference [$F(9,4) = 4.02$, $p < 0.05$] in plantar flexion peak torque between treatments at 30° and 120°, but not at 180°. At 30° peak torques generated for the Air-Stirrup, Active Ankle, protective tape, and Swede-O-Universal treatments were 11 to 19 percent less than the control. At 120°, the Air-Stirrup, Active Ankle, tape, and Swede-O-Universal treatments were 3 to 18 percent less than the mean control peak torque value. Peak torque data at 180° indicated that the Air-Stirrup, Swede-O-Universal, and tape treatments ranged from 9 to 21 percent less than the control treatment. The Active Ankle treatment was 7.8 percent greater than the control treatment mean value.

The mean dorsiflexion peak torque were not significantly different (Table 1). The percent of difference between the control and other experimental treatments ranged from 1 to 22 percent.

**Table 1. Peak torque percent of body weight mean and standard deviation values**

| SPEED | NOS | AC | AA | SW | TP |
|---|---|---|---|---|---|
| | | | (Nm/kg) | | |
| **PLANTAR FLEXION** | | | | | |
| 30°/sec | 72.5[d] | 61.1 | 64.3[d] | 58.7[ac] | 62.9 |
| | (10.8) | (12.7) | (17.6) | (15.18) | (12.2) |
| 120°/sec | 40.7[d] | 34.3 | 39.5[d] | 30.0[ac] | 33.4 |
| | (10.6) | (4.3) | (10.8) | (8.4) | (7.3) |
| 180°/sec | 29.3 | 26.7 | 31.6 | 24.3 | 23.3 |
| | (8.4) | (3.4) | (13.9) | (6.1) | (7.2) |
| **DORSIFLEXION** | | | | | |
| 30°/sec | 17.5 | 15.7 | 17.8 | 16.8 | 17.1 |
| | 2.0 | 2.6 | 3.1 | 2.7 | 2.2 |
| 120°/sec | 9.8 | 8.5 | 11.4 | 9.1 | 8.7 |
| | 1.2 | 1.8 | 3.9 | 2.3 | 1.5 |
| 180°/sec | 6.5 | 6.8 | 8.1 | 5.8 | 5.8 |
| | 1.5 | 2.2 | 6.6 | 1.6 | 1.2 |

No Support (NOS)
Air Stirrup (AC)
Active Ankle (AA)
Swede-O (SW)
Tape (TP)

a = significantly different ($p < 0.05$) from No Support (NOS)
b = significantly different ($p < 0.05$) from Air Stirrup (AC)
c = significantly different ($p < 0.05$) from Active Ankle (AA)
d = significantly different ($p < 0.05$) from Swede-O (SW)
e = significantly different ($p < 0.05$) from Tape (TP)

**Table 2. Plantar flexion and dorsiflexion total work mean and standard deviation values**

| NOS | AC | AA | SW | TP |
|---|---|---|---|---|
| | | (Nm) | | |
| **PLANTAR FLEXION** | | | | |
| 409.3[de] | 367.8 | 393.4[de] | 310.0[ac] | 312.6[ac] |
| (133.3) | (129.3) | (177.5) | (149.9) | 139.2) |
| **DORSIFLEXION** | | | | |
| 74.2 | 63.8 | 71.2 | 49.2 | 64.3 |
| (36.6) | (28.6) | (36.7) | (21.0) | (26.8) |

a = significantly different ($p < 0.05$) from No Support (NOS)
b = significantly different ($p < 0.05$) from Air Stirrup (AC)
c = significantly different ($p < 0.05$) from Active Ankle (AA)
d = significantly different ($p < 0.05$) from Swede-O (SW)
e = significantly different ($p < 0.05$) from Tape (TP)

The mean values of plantar flexion total work performed are presented in Table 2. There was a significant difference [$F(9,4)=6.02$, $p<0.05$] between plantar flexion treatments. Plantar flexion total work for the experimental conditions was 4 to 24 percent of the control condition.

**Table 3. Average, maximum, and passive range of motion mean and standard deviation values**

| SPEED | NOS | AC | AA | SW | TP |
|---|---|---|---|---|---|
| | | | (degrees) | | |
| **AVERAGE ROM** | | | | | |
| 30°/sec | 55.7[d] (11.3) | 52.8 (16.7) | 53.8 (14.0) | 47.7[a] (15.0) | 51.6 (12.4) |
| 120°/sec | 61.7[bde] (5.8) | 55.1[a] (7.3) | 59.2 (8.8) | 54.8[a] (7.1) | 54.0 (6.2) |
| 180°/sec | 56.0[de] (6.4) | 52.4 (4.9) | 54.6[d] (8.6) | 49.1[ac] (6.9) | 50.0[a] (6.2) |
| **MAXIMUM ROM** | | | | | |
| 30°sec | 63.0[d] (11.5) | 59.0 (16.7) | 61.0 (13.9) | 54.8[a] (16.6) | 58.5 (12.6) |
| 120°/sec | 67.1[e] (6.3) | 61.2 (7.9) | 65.1 (9.2) | 61.2 (7.9) | 60.4[a] (6.6) |
| 180°/sec | 64.8[d] (5.7) | 61.7 (6.7) | 63.5 (7.7) | 59.0[a] (8.2) | 59.8 (5.4) |
| **PASSIVE PLANTAR FLEXION ROM** | | | | | |
| | 38.6[bcde] (6.1) | 33.8[ad] (6.7) | 33.3[ad] (5.9) | 28.1[abd] (5.0) | 32.6[ad] (7.6) |
| **PASSIVE DORSIFLEXION ROM** | | | | | |
| | 12.7[dce] (4.9) | 9.9 (4.1) | 12.1 (4.5) | 9.4[a] (2.9) | 9.7[a] (3.9) |

a = significantly different ($p < 0.05$) from No Support (NOS)
b = significantly different ($p < 0.05$) from Air Stirrup (AC)
c = significantly different ($p < 0.05$) from Active Ankle (AA)
d = significantly different ($p < 0.05$) from Swede-O (SW)
e = significantly different ($p < 0.05$) from Tape (TP)

There was no significant difference [F (9,4) = 3.44, p > 0.05] in dorsiflexion total between conditions. The experimental conditions were 4 to 34 percent less than the control condition.

Table 3 contains mean values for average ROM as measured by the isokinetic dynamometer at the three speeds of movement. There was no significant difference [F (9,4) = 3.21, p < 0.05] between treatments at any of the speeds.

Maximum ROM is defined as the difference between maximum plantar flexion and dorsiflexion angular values. The percentage difference between the control treatment and the other treatments ranged from 4 to 2 percent at 30°, 3 to 10 percent at 120°, and 4 to 9 percent at 180°.

Average passive ROM values for both plantar flexion and dorsiflexion are presented in Table 3. Plantar flexion ROM was significantly greater [F (9,4) = 5.88, p < 0.05] in the control group than the other experimental treatments. The difference between them ranged from 11 to 27 percent.

Dorsiflexion ROM was significantly greater [F (9.4) = 5.68, P < 0.05] in the control group than all other treatment groups except the Active Ankle. The percentage of difference ranged from 5 to 27 percent.

## DISCUSSION

The results of this study indicate that plantar flexion total work is affected by some supportive devices. If we consider: performance to be related to plantar flexion total work, then our tape wrap total work test results are supported by others who found that ankle tape wraps inhibit motor performances (7, 9, 10).

The plantar flexion peak torque results of this study agree with the findings of Abdenour et al. (1) and Fisher (3) who found that ankle tape wraps do not inhibit ankle plantar flexion strength. In addition, our data indicate that some types of prophylactic ankle devices inhibited the production of peak isokinetic torque at 30° and 120° movement speeds.

Perhaps an athlete should use different types of ankle protection depending on the activity situation. In activities which require maximum plantar flexion strength, a protective device that does not inhibit strength should be used. However, if the activity requires maximum ankle joint total work, a different type of protective device should be used. An activity that requires both strength and total work requires a third type of ankle protection device.

One explanation for finding no significant difference between the dorsiflexion strength tests may be related to the small range of values between dorsiflexion tests.

There are two possible hypotheses concerning the effectiveness of ankle joint supportive devices and ROM. One hypothesis is that a device is more effective if the ROM is restricted, thereby limiting at risk movement. The other hypothesis is that a device is more effective if plantar flexion and dorsiflexion ROM were restricted only when normal ROM limits were exceeded. If the latter hypothesis is accepted, then the Active Ankle and Air-Stirrup braces appear to be the better devices in allowing full ROM. With the exception of plantar flexion and dorsiflexion flexibility tests, the Active Ankle brace was the closest to wearing no brace at all. The tape and Swede-O-Universal braces consistently limited the ROM. This is probably a result of the design of the support device (i.e., restriction in front and in the back of the joint).

In conclusion, these results suggest that the selected ankle joint prophylactic guards tested under these conditions differ in their ability to provide normal isokinetic torque production, total work, and active and passive ROM. In addition, the results presented here indicate that there are significant differences among ankle prophylactic devices in peak ankle torque production, total work, and active and passive ROM.

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