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Effects of a Tape Cast, Air-Stirrup, and an Air-Stirrup Applied Over a Taped Ankle on Dynamic Ankle Inversion

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EFFECTS OF A TAPE CAST, AIR-STIRRUP, AND AN AIR-STIRRUP APPLIED OVER A TAPED ANKLE ON DYNAMIC ANKLE INVERSION

by

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GRADUATE COMMITTEE APPROVAL

of a thesis submitted by

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This thesis has been read by each member of the following graduate committee, and by majority vote has been found to be satisfactory.

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As chair of the candidate's graduate committee, I have read the thesis of Justin K. Freeman in its final form and have found that (1) its format, citations, and bibliographical style are consistent and acceptable and fulfill university and department style requirements; (2) its illustrative materials, including figures, tables, and charts, are in place; and (3) the final manuscript is satisfactory to the graduate committee and is ready for submission to the university library.

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ABSTRACT

EFFECTS OF A TAPE CAST, AIR-STIRRUP, AND AN AIR-STIRRUP APPLIED OVER A TAPED ANKLE ON DYNAMIC ANKLE INVERSION

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Master of Science

Objective: To compare the tape cast, and an Air-Stirrup/closed basketweave combination to the Air-Stirrup alone with respect to their effects on dynamic ankle inversion.

Design and Setting: This study used a repeated measures design with the independent variables being the exercise bout and the ankle support method (4 levels: no support, Air-Stirrup only, Air-Stirrup/closed basketweave, and tape cast). The 2 dependent variables were total inversion and maximum inversion velocity. Measurements were taken before and after an exercise bout, and all trials were conducted in the university's human performance laboratory.

Subjects: 16 subjects (11 male, 5 female, age 24.3 ± 1.8 years) with no ankle injury within 6 months prior to participation participated in this study.

Measurements: Subjects stood on an inversion platform, which rotated 37° in the frontal plane, creating dynamic inversion of the ankle. Total inversion and maximum inversion velocity were calculated using electrogoniometers. A linear growth curve was used to model pre to post exercise differences.

Results: There was a significant difference between the control and the 3 support methods for both variables. The effects of the Air-Stirrup/closed basketweave were similar to the effects of the Air-Stirrup alone. There was no significant difference between the tape cast and the Air-Stirrup.

Conclusions: All 3 support methods significantly reduce total ankle inversion and maximum inversion velocity. When compared with the Air-Stirrup alone, the tape cast and the tape/brace combination both are similar in their effects on total ankle inversion and maximum inversion velocity.

Key Words: inversion platform, moleskin, air cast

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Key Words: inversion platform, moleskin, air cast

INTRODUCTION

Though a primary duty of an athletic trainer is the prevention of injury, injuries do inevitably occur. It then becomes the athletic trainer's goal to prepare the athlete for return to participation, using methods that will protect the athlete from aggravating the injury during rehabilitation, and, upon return to participation, to prevent reinjury.[1,2]

The most commonly injured joint in sports is the ankle, comprising 20-25% of all injuries associated with loss of training time.[1,3] The lateral, or inversion sprain, is the most common ankle injury.[1-8] Taping and bracing have been used both prophylactically against first time ankle injuries,[1,2] and for preventing reinjury.[1-3] A variety of braces and taping methods exist to support the ankle, including the Air-Stirrup (Aircast, Inc. Summit, NJ) and a taping procedure called the "tape cast."

Both the Air-Stirrup and the tape cast may be used to provide more external support to the ankle than conventional taping alone. This additional support may better protect athletes who have not yet completed the repair phase of healing following injury as they return to participation. Functional management of ankle sprains (introducing and encouraging as much function as possible throughout the injury healing process) has been shown to decrease recovery time, allowing for a quicker return to activity.[9-15] Focusing on early mobility is crucial to achieving optimal function, as well as long term ankle stability.[8] Therefore, the athlete should be allowed to return to activity as soon as possible.[16] When treating injuries this way, protected function is the key,[14] serving to bridge the gap between early healing and a full recovery, if the functional activities are protected and initiated gradually.[17] Early aggressive treatment may allow return to participation within a few days,[17] though not at full strength. Successful functional

management of ankle sprains is facilitated by using one of various taping techniques or braces, including the Air-Stirrup, to provide additional joint stabilization.[1]

The Air-Stirrup has been used both prophylactically and post injury. The inflatable air cells allow ambulation with both compression and protection, while at the same time allowing motion in a range that is safe for the injured ligaments.[8] Use of the Air-Stirrup in this way reduces recovery time, thus facilitating an earlier return to activity than immobilization.[10,11,14,15] It has also been reported that use of the Air-Stirrup reduces the incidence of ankle injuries.[18,19]

Previous studies have confirmed the ability of the Air-Stirrup to resist ankle inversion.[7,18,20-22] However, a review of the literature revealed no studies examining how effective an Air-Stirrup, applied over a taped ankle, would be at resisting inversion, nor were there any studies examining how effective a tape cast, alone, would resist inversion. In addition, there are no published studies to date that compare the Air-Stirrup, the Air-Stirrup applied over tape, and the tape cast with regard to their respective resistive effects on dynamic ankle inversion. Therefore, the purpose of this study was to compare two support methods that had never been tested before (tape cast, and Air-Stirrup/tape combination) to the Air-Stirrup alone with respect to their pre exercise effects on total inversion and maximum inversion velocity, and changes in both variables due to exercise.

METHODS

Subjects

Sixteen subjects (11 male and 5 female, age 24.3 ± 1.8 years, height 173.8 ± 8.1 cm, weight 75.0 ± 11.5 kg) voluntarily participated in this study. All subjects had no

history of ankle injury within 6 months prior to participation, and each subject completed the Physical Activities Readiness Questionnaire[23] form prior to participating. Each subject gave written informed consent, and the project was approved by the university human subjects review board.

Equipment

We used an inversion platform in an attempt to better replicate the dynamic inversion component of a lateral ankle sprain. The inversion platform used in this study was equipped with a hand-held button that was electronically attached to a magnetic release mechanism on the trap door of the platform. When the release mechanism was activated, gravity caused the foot-support base of the platform to rotate 37° on the anterior-posterior axis (frontal plane), creating a dynamic inversion force on the ankle. The inversion platform we used was similar in design and function to inversion platforms used in other studies.[4,21,24-29] An electrogoniometer was built into the platform, from the base support to the trap door, to measure the rate, distance and time of the trap door fall.

Another electrogoniometer was attached to the heel of the subject's shoe and to the gastrocnemius in line with the Achilles tendon to measure the ankle inversion as a function of time (Figure 1). Ricard et al established the validity of using a goniometer attached to the shoe in a previous study.[25]

Due to the fragile nature of the instrumentation, and the potential that the exercise bout would alter the position of the goniometer, the goniometer was removed for exercise. In order to eliminate any errors that may have resulted from the subsequent replacement of the goniometer after exercise, it was zeroed with the subject's right ankle in their pre drop weightbearing position prior to each trial (Figure 2).

Surface electromyography (EMG) was used to record the level of activity of the peroneus longus to assure that there was no muscle contraction prior to activation of the trap door. EMG and goniometer signals were sampled at 1000 Hz using a Micron P-133 computer interfaced to a Noraxon (Scottsdale, AZ) EMG amplifier by a Keithley-Metrabyte (Taunton, MA) 1802 HC, 64-channel, 12-bit analog-to-digital converter. The EMG signals were recorded with Noraxon bipolar Ag/AgCl surface electrodes (Noraxon Dual Electrode, Product #272). The EMG signals were differentially amplified with a gain of 1000 and a bandwidth of 16-500 Hz at -3dB using a Noraxon Telemyo telemetry system. The Noraxon amplifiers have an input noise below 1 μV RMS and an effective common mode rejection ratio of 135 dB.

Procedures

Testing sessions began with EMG electrode placement on the subject's right leg. The electrode sites were prepared by shaving the hair, lightly abrading the skin with a gauze pad and cleansing the area with rubbing alcohol to lower input impedance below 3000 Ω. Electrodes were then centered over the approximate middle of the muscle belly of the peroneus longus muscle. The electrodes were placed in a vertical fashion, in pairs 2 cm apart from center to center. A single ground electrode was placed directly over the head of the right fibula (Figure 3). The electrode positions were marked with a permanent marker for accurate repositioning in future trials. These marks were re-established at the conclusion of each testing session, and each subject was instructed to re-mark them, if needed, after bathing, for the duration of their participation in the study.

Once the electrodes were in place, the subject's right ankle was fitted with the support method they would be testing that day. Each subject was tested under 4

conditions: no tape (control), Air-Stirrup only (brace), Air-Stirrup with the ankle taped underneath (brace/tape), and tape cast. The same certified athletic trainer applied each support method to each subject. The treatment order was randomly assigned using a balanced Latin square. The testing of each condition took place on separate days, no less than 2 days, and no more than 4 days apart, and all testing sessions for each subject were completed within a 3 week period.

Each subject wore K-Swiss (Westlake Village, CA) Lozan low-top athletic shoes, which were provided, for all testing sessions. Under the control condition, each subject was tested wearing socks with the shoes tightly laced. When testing the brace condition, the Air-Stirrup was worn over a sock, but inside a tightly laced shoe, according to product instructions.

Under the brace/tape condition, the subject's right ankle was taped with 3.8 cm (1.5 in) zinc oxide tape (Jaybird & Mais, Inc. Lawrence, MA). Before application of the tape, the Air-Stirrup was applied and a line was traced with a permanent marker onto the leg along the top of the Air-Stirrup, marking its height for future reference. After removing the Air-Stirrup, tape adherent (Mueller Sports Medicine, Inc. Prairie du Sac, WI) was sprayed over the entire area to be taped and allowed to dry a few seconds. Lubricated heel and lace pads (Cramer Products, Inc. Gardner, KS) were then placed directly over the Achilles tendon and anterior ankle. With the subject's foot at a 90° angle to the lower leg (neutral), underwrap (Mueller Sports Medicine) was applied starting at approximately the base of the fifth metatarsal and wrapping around circumferentially up the ankle and leg, ending approximately 2.5 cm below the reference mark. Tape anchors were placed circumferentially around the leg with the top anchor

starting at the reference mark, and the other anchor placed just posterior to the base of the fifth metatarsal. Taping then proceeded in a closed basketweave fashion, as described in Arnheim.[2] A sock was worn over the tape, with the brace being worn over the sock and inside the tightly laced shoe.

The tape cast condition was also applied with the foot of the subject in the neutral position. The spray and pads were applied in the same manner as with the other taping treatment, but instead of underwrap, 7.6 cm (3 in) conforming Jaylastic Athletic Stretch Tape (Jaybird & Mais) was applied in the same manner as the underwrap. A 7.6 cm (3 in) wide single moleskin stirrup (Protekto, Jesup, GA) was then applied medial to lateral (Figure 4), followed by the application of 5 cm (2 in) zinc oxide tape (Jaybird & Mais) in the same manner as the closed basketweave. However, two continuous heel lock/figure-eight combinations were applied using 7.6 cm (3 in) Jaylastic Plus II semi-elastic brown stretch tape (Jaybird & Mais) before the heel locks were applied with the zinc oxide tape (Figure 5). The tape cast was completed by applying heel locks, figure-eights, and re-anchoring strips, as done with the closed basketweave, using the 5 cm zinc oxide tape (Figure 6). A sock was worn over the tape cast and the shoe was worn, tightly laced, over the sock.

After being fitted with a method of support, the subject was asked to stand on the inversion platform. The goniometer was then attached to the rear of the subject's shoe and to the gastrocnemius in line with the Achilles tendon, and the EMG electrodes were attached to the telemetry system. The subject's right foot was strapped tightly against the side bar on the surface of the platform using a hook and loop fastener strap to prevent the foot from sliding across the surface of the platform. The subject stood facing away from

the testers to avoid anticipation of the platform drop, and was instructed to stand with their weight on the right foot, using the left great toe for balance, until the platform dropped (Figure 2). The platform was dropped (Figure 7) at random intervals and the subject was instructed to "ride" the platform into the resultant inversion that occurred (ie, not to attempt to stop the motion by activating the muscles). The goniometer was zeroed prior to each trial, and the subject was repeatedly dropped into inversion until 5 acceptable trials were recorded. Trials were only recorded and saved for analysis if there was no EMG evidence of muscle preactivation.

Following the platform trials, the subject participated in an exercise bout designed to stress the support methods in a way similar to what would be experienced by an athlete in-season. The exercise bout consisted of:

1. A 5 minute warm-up treadmill run at 8.05 kph (5 mph).
2. 3 sets of 15.4 m (50 ft) shuttle runs (7 times across the width of a regulation size basketball court) in 30 seconds or less, with 90 seconds rest between sets. Subjects were instructed to push off the supported leg when changing directions.
3. Three sets of 3.7 m (12 ft) lateral slide shuttles (15 times back and forth across the width of the key) in 20 seconds or less, with 60 seconds rest between sets.
4. Six sets of 28.9 m (94 ft) "combination sprints" in 8 seconds or less, with 25 seconds rest between sets. Three sets were performed with the subject starting on the baseline, sprinting forward 14.5 m (47 ft) to halfcourt, turning around on the supported leg, and backpedaling the remaining distance to the opposite baseline. These sets were alternated with 3 sets that were performed in an opposite manner. The "opposite" sets were performed with the subject starting on the baseline,

backpedaling to halfcourt, turning on the supported leg, and sprinting forward the remaining distance to the opposite baseline.

5. 3 sets of 15 vertical jumps off both feet, in 15 seconds or less, with 45 seconds rest between sets. Each subject was instructed to attempt to touch the backboard of a basketball standard with each jump.

A 2 minute rest was allowed between exercises, and the entire exercise bout, including the treadmill warm-up, took approximately 25 minutes.

Following the exercise bout, post exercise measurements were taken on the inversion platform, using the same procedures as before, until 5 acceptable trials were recorded. At the conclusion of the testing session, the goniometer and electrodes were removed and the electrode positions were re-marked to ensure consistent replacement in the next session.

Design and Statistical Analysis

This study used a repeated measures design, with the independent variables being the exercise bout and the ankle support method (4 levels: control or no support, Air-Stirrup only, Air-Stirrup applied over a taped ankle, and tape cast). Our 2 dependent variables were total inversion (measured in degrees) and maximum inversion velocity (°/s). Total inversion was defined as the difference between initial joint angle (prior to dropping the inversion platform) and the maximum inversion point reached following platform drop. The maximum inversion velocity was defined as the greatest velocity obtained between platform drop and the maximum inversion point.

Data were analyzed using SAS Proc Mixed (SAS Institute, Inc., Cary, NC) to appropriately account for both within and between subject covariances. A linear growth

curve was used to model pre to post exercise differences. Intercepts of these curves are estimates of pre exercise response, while slopes estimate changes in responses from pre to post exercise. Variance components were estimated for subjects, subject by treatment interaction, and subject by time interaction. The within subject covariance structure was assumed to be of the compound symmetric type. Degrees of freedom and inflation of estimated covariance structure were adjusted using the method suggested by Kenward and Roger.[30] Although α was set at $P = .05$ for all comparisons, a Bonferroni correction factor was used to account for the multiple *t* tests between conditions. The adjusted α level was $P = .004$.

RESULTS

Table 1 gives pre exercise estimates and standard errors of total inversion and increases in total inversion due to exercise, and Figure 8 illustrates these increases. Both the tape cast and Air-Stirrup showed a significant increase in total inversion due to exercise, but the control and tape/brace conditions did not.

Pre exercise estimates of inversion for the control condition were significantly greater than the inversion allowed by the support methods (Table 2). Before adjusting for multiple tests, the Air-Stirrup allowed significantly less inversion pre exercise than the tape cast, but after the adjustment, they were similar. The tape cast also allowed significantly more inversion pre exercise than the tape/brace condition before and after the Bonferroni correction. The Air-Stirrup and tape/brace conditions allowed similar amounts of inversion before exercise, and all 4 conditions showed a similar increase in the amount of inversion due to exercise.

Table 3 gives pre exercise estimates and standard errors of maximum inversion velocity and increases in maximum inversion velocity due to exercise, and Figure 9 illustrates these increases. The inversion velocity increases due to exercise were significant for the Air-Stirrup and tape cast, but insignificant for the control and tape/brace conditions.

Pre exercise estimates of maximum inversion velocity for the control were significantly greater than for the support methods (Table 4). However, between the support methods, there was no significant difference in pre exercise maximum inversion velocity. The control allowed a greater increase in maximum inversion velocity due to exercise than the tape/brace condition, but the difference was not significant. Likewise, the tape cast allowed a greater increase in maximum inversion velocity due to exercise than the Air-Stirrup, but their difference was not significant either. Before adjusting for multiple tests, the tape cast and Air-Stirrup each showed significantly greater increases in maximum inversion velocity due to exercise than the control condition. They also both showed significantly greater increases in maximum inversion velocity due to exercise than the tape/brace condition. However, after the Bonferroni correction, these differences were no longer significant.

DISCUSSION

Lateral ankle sprains are one of the most common injuries in sports.[1-8] Plantar flexion, combined with inversion, is the most common mechanism of injury,[1-3,5,6] being responsible for 85% of all ankle sprains.[5,31] This prevalence of ankle injuries in sports, has prompted clinicians to develop various means of external ankle support, with the

intention of protecting the ankle ligaments while allowing for normal function.[32] These efforts have led to the development of different taping techniques, soft re-useable braces, and semi-rigid plastic braces.

Previous studies have reported that taping and bracing maximally resist movement immediately after application, and upon activity, begin to lose their restrictive ability.[6,20,22,24,25,32-40] Since inversion measurements increase even when there is no external support in place, increased inversion measurements after exercise may be the result of both an increased extensibility of the ankle soft tissue after being "warmed up," and a "loosening" of the support method itself.[25] However, Wilkerson[40] suggested that for injury prevention, limitation of motion may only be required near the limits of normal range of motion. Ricard et al[25] felt that though tape does loosen during exercise, ankle taping still provides residual restriction. Thus, the loosening of the support method may not necessarily eliminate its protective effect.

It is interesting to note that all of our conditions demonstrated a similar increase in total inversion due to exercise (Table 2). The tape cast and Air-Stirrup loosened the most with exercise (Table 1), but the increases in inversion were not significant when our α level was adjusted for multiple comparisons. Ricard et al[25] noted that about 50% of the reported loosening of the tape after exercise was perhaps due to increased extensibility of the ankle connective tissue. When we compared the loosening that occurred with our non-taped condition to the loosening experienced by our highly restrictive support methods, increased extensibility of the ankle connective tissue could possibly account for approximately 30-50% of the loosening reported (Table 1).

Our study concurs with other studies that the Air-Stirrup significantly resists inversion.[7,18,20-22] Taping the ankle prior to applying the Air-Stirrup did not make a significant difference in total inversion before or after exercise. However, the combination of tape and the brace did provide significantly greater resistance to inversion pre exercise than did the tape cast. While the tape cast allowed more inversion before exercise than did the Air-Stirrup, after the α level was adjusted for multiple tests (P=.004), the effects of the tape cast and Air-Stirrup were statistically similar (Table 2).

The tape cast was also similar to the Air-Stirrup in both pre exercise maximum inversion velocity, and the increase in maximum inversion velocity due to exercise (Table 4). Both showed a significant increase in maximum inversion velocity (Table 3). The tape/brace condition experienced the smallest increase in maximum inversion velocity, and before adjusting for multiple tests it was significantly different from the other 2 support methods.

Figures 8 and 9 illustrate a pattern in the ranking order of the effects of the support conditions on total inversion and maximum inversion velocity. The tape/brace condition allowed less inversion and a slower inversion velocity than the other conditions, except for pre exercise maximum inversion velocity, where it was essentially the same as the tape cast and the Air-Stirrup (Figure 9). The AirSirrup allowed a little more inversion and a faster velocity than the tape/brace condition, but less inversion and a slower velocity than what was allowed by the tape cast. The control condition allowed the most inversion and the fastest inversion velocity compared with the other conditions.

The statistical significance of the differences between the tape cast, Air-Stirrup, and tape/brace conditions varies, depending on the α level used. However, statistical

significance may be misleading. For example, when comparing pre exercise total inversion, the tape cast allowed 3.44° more inversion than the Air-Stirrup. This difference was significant at P=.05, but not at P=.004. Whether statistically significant or not, a 3.44° difference may not be clinically significant, considering the total amount of inversion being recorded. Therefore, what is important to note is that while the small differences between the tape cast, Air-Stirrup, and tape/brace conditions may or may not be statistically significant, all 3 allow significantly less inversion than the control condition.

It is also important to note that there were significant differences in maximum inversion velocity pre exercise between the three support methods and the control. The fact that the 3 support methods allowed a significantly slower (approximately 33% slower) maximum inversion velocity is important when considering injury prevention. It has been reported that it takes the peroneal muscles 115 milliseconds to impose a force substantial enough to cause a response to inversion,[4,25] so many ankle sprains occur before the muscles can react in an attempt to protect the joint.[25] Konradson et al[4] suggested that during a sudden inversion force, the muscles causing eversion cannot prevent the ankle from inverting. However, since force is directly proportional to acceleration, decreasing the maximum inversion velocity by one-third should effectively decrease the potential severity of an ankle sprain

Our data showed a greater amount of inversion than reported in other studies which compared ankle taping with different types of braces.[20,22,32,35-37] However, all but one of these studies tested passive inversion with their subjects in a non-weightbearing

position, as opposed to weightbearing dynamic ankle inversion in our study. Martin and Harter[22] tested their subjects in a weightbearing position, but they used a treadmill tilted at 8.5°, far less than our 37° platform.

Although our platform stopped at 37°, our recorded inversion measurements far exceeded 37°. One reason for this discrepancy is that after the platform stops, the ankle continues to invert due to inertia of the subject's center of mass.[29] Another contributing factor was the starting position of the subjects' ankle being tested. Asking each subject to put all their weight on one leg forced their center of mass to shift laterally, thus producing eversion at the ankle joint and on the goniometer (Figure 2). The goniometer was zeroed at this point, to reduce differences between trials. Therefore, when the platform was dropped, the resulting inversion measurement was not a true measure of inversion at the ankle, but rather a measure of total frontal plane range of motion.

This study was designed to examine the effectiveness of different methods of ankle support at resisting dynamic ankle inversion due to exercise, but testing was performed in a controlled setting, which may not accurately represent conditions on the playing field. Although the ankle was dropped into inversion, we did not produce the plantar flexion and external rotation of the lower leg, which usually accompany inversion in the mechanism of injury for most ankle sprains.[1-3,5,6,31]

A further limitation of this study was that the absence of muscle preactivation was not constant. Regardless of support condition and subject being tested, some testing sessions required more trials than others to get acceptable data. Though the number of trials needed to achieve the 5 trials acceptable for recording ranged from 5 to 15, the majority of testing sessions yielded 5 acceptable trials in 8 to 12 attempts. The

variance in trials could possibly have affected the integrity of the particular support method being tested, but we feel this effect was equally distributed across all conditions.

CONCLUSIONS

The tape cast, Air-Stirrup, and an Air-Stirrup worn over a taped ankle all provide significant inversion restriction and decrease in inversion velocity compared with no support. The Air-Stirrup worn over a taped ankle was the best method tested at resisting inversion and reducing inversion velocity. The Air-Stirrup alone allowed a little more inversion and a faster velocity than the tape/brace condition, but less inversion and a slower velocity than what was allowed by the tape cast. However, the differences between these three support methods may not be clinically significant.

Wearing a tape application underneath an Air-Stirrup provided more inversion restriction and allowed a smaller increase in inversion velocity over time than the Air-Stirrup alone, but these differences were not significant. The differences between the effects of the tape cast and the effects of the Air-Stirrup on total inversion and maximum inversion velocity were not significant either.

All the support methods we tested are effective at reducing total inversion and maximum inversion velocity, and thus are viable options to consider for facilitating the functional management of an ankle injury. Suggestions for further research would be to test these support methods with a plantarflexion component during inversion testing, and to compare the tape cast and tape/brace combination with standard ankle taping.

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Table 1. Total inversion (°)

Treatment	Estimate	Standard Error	DF	t Value	Pr > |t|
Pre-exercise					
control	61.88	1.24			
tape cast	52.68	1.24			
Air-Stirrup	49.24	1.24			
tape & brace	48.00	1.24			
Increases Due to Exercise					
control	0.87	1.22	58.1	-0.72	0.48
tape cast	2.98	1.22	58.1	-2.45	0.018*
Air-Stirrup	2.87	1.22	58.1	-2.35	0.022*
tape & brace	1.67	1.22	58.1	-1.37	0.18

*significant at $P = .05$

Table 2. Differences in Total Inversion (°) Between Treatments

Treatments	Estimate	Standard Error	DF	t Value	Pr > |t|
Pre-exercise					
C v TC	9.20	1.38	82.7	-6.69	<.0001#
C v AS	12.64	1.38	82.7	-9.19	<.0001#
C v T/B	13.88	1.38	82.7	-10.09	<.0001#
TC v AS	3.44	1.38	82.7	-2.50	0.015*
TC v T/B	4.67	1.38	82.7	-3.40	0.001#
AS v T/B	1.24	1.38	82.7	-0.90	0.37
Increases Due to Exercise					
C v TC	2.11	1.63	45	1.29	0.20
C v AS	2.00	1.63	45	1.22	0.23
C v T/B	0.80	1.63	45	0.49	0.63
TC v AS	0.11	1.63	45	-0.07	0.95
TC v T/B	1.31	1.63	45	-0.80	0.43
AS v T/B	1.20	1.63	45	-0.73	0.47

significant at $P = .004$

* significant at $P = .05$, but not significant after Bonferroni correction ($P = .004$)

C = control, TC = tape cast, AS = Air-Stirrup, T/B = tape + brace

Table 3. Maximum inversion velocity (°/s)

Treatment	Estimate	Standard Error	DF	t Value	Pr > |t|
Pre-exercise					
control	749.04	21.59			
tape cast	499.67	21.59			
Air-Stirrup	478.23	21.59			
tape & brace	486.83	21.59			
Increases Due to Exercise					
control	18.50	20.48	40.4	-0.90	0.37
tape cast	75.98	20.48	40.4	-3.71	0.0006[#]
Air-Stirrup	65.49	20.48	40.4	-3.20	0.003[#]
tape & brace	17.03	20.48	40.4	-0.83	0.41

[#] significant at $P = .004$

Table 4. Differences in Maximum Inversion Velocity (°/s) Between Treatments

Treatment	Estimate	Standard Error	DF	t Value	Pr > |t|
Pre-exercise					
C v TC	249.37	26.87	63.1	-9.28	<.0001#
C v AS	270.80	26.87	63.1	-10.08	<.0001#
C v T/B	262.21	26.87	63.1	-9.76	<.0001#
TC v AS	21.44	26.87	63.1	-0.80	0.43
TC v T/B	12.84	26.87	63.1	-0.48	0.63
AS v T/B	8.60	26.87	63.1	0.32	0.75
Increases Due to Exercise					
C v TC	57.49	22.40	45	2.57	0.014*
C v AS	47.00	22.40	45	-23.14	0.042*
C v T/B	1.46	22.40	45	-0.07	0.95
TC v AS	10.49	22.40	45	-0.47	0.64
TC v T/B	58.95	22.40	45	-2.63	0.012*
AS v T/B	48.46	22.40	45	-2.16	0.04*

significant at $P = .004$

* significant at $P = .05$, but not significant after Bonferroni correction ($P = .004$)

C = control, TC = tape cast, AS = Air-Stirrup, T/B = tape + brace

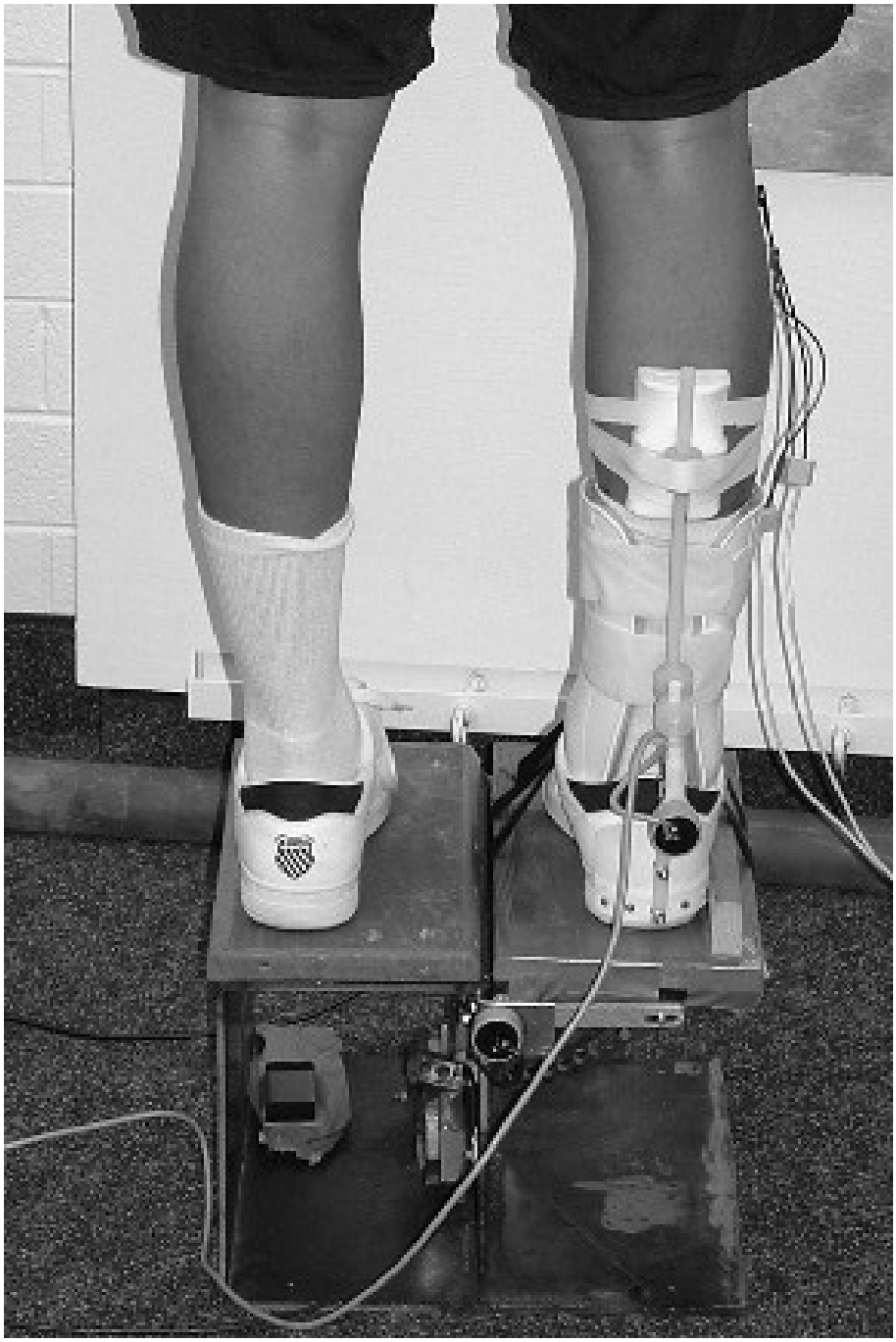

Figure 1. An electrogoniometer is attached to the subject's shoe and to the gastrocnemius in line with the Achilles tendon.

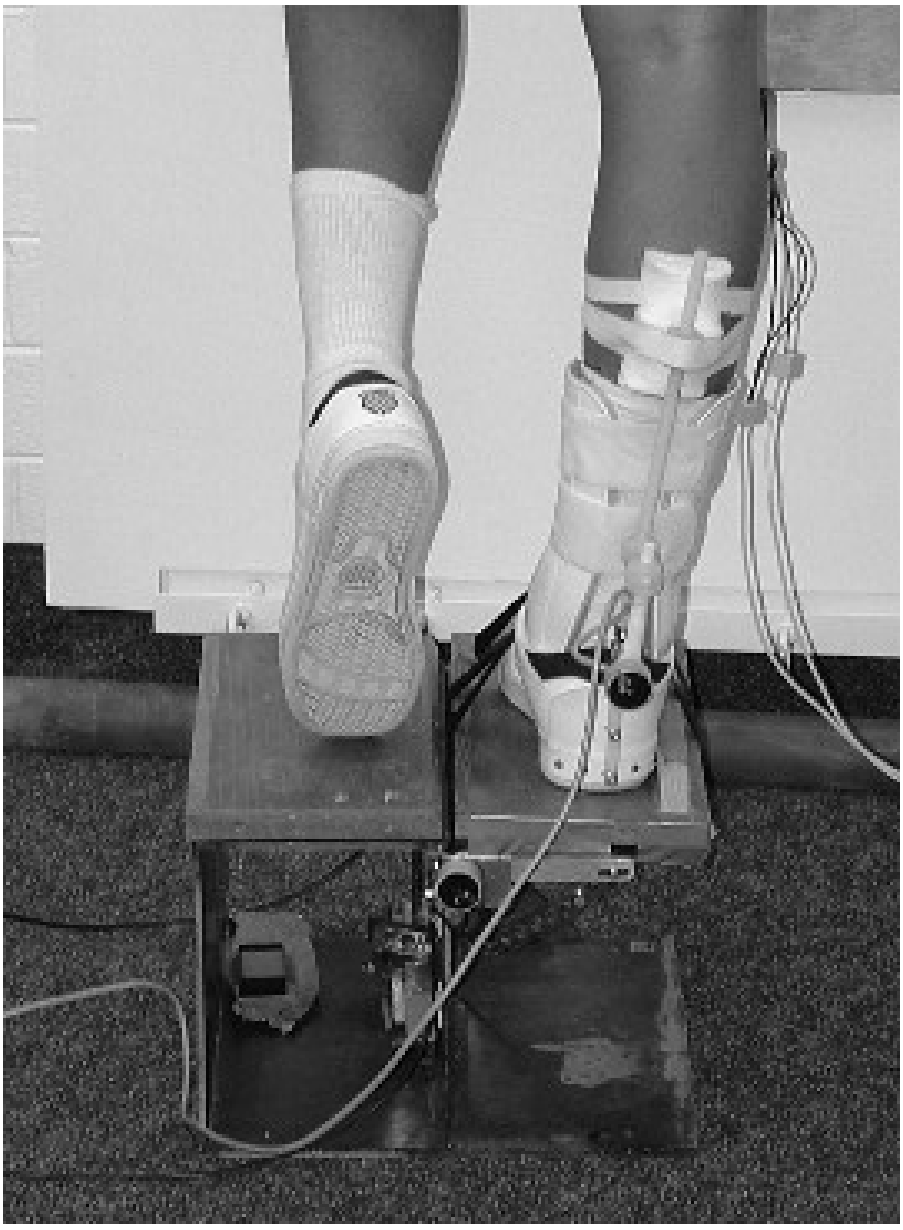

Figure 2. The subject stands with their weight on the right foot, using the left great toe for balance. The electrogoniometer was zeroed in this position prior to each trial.

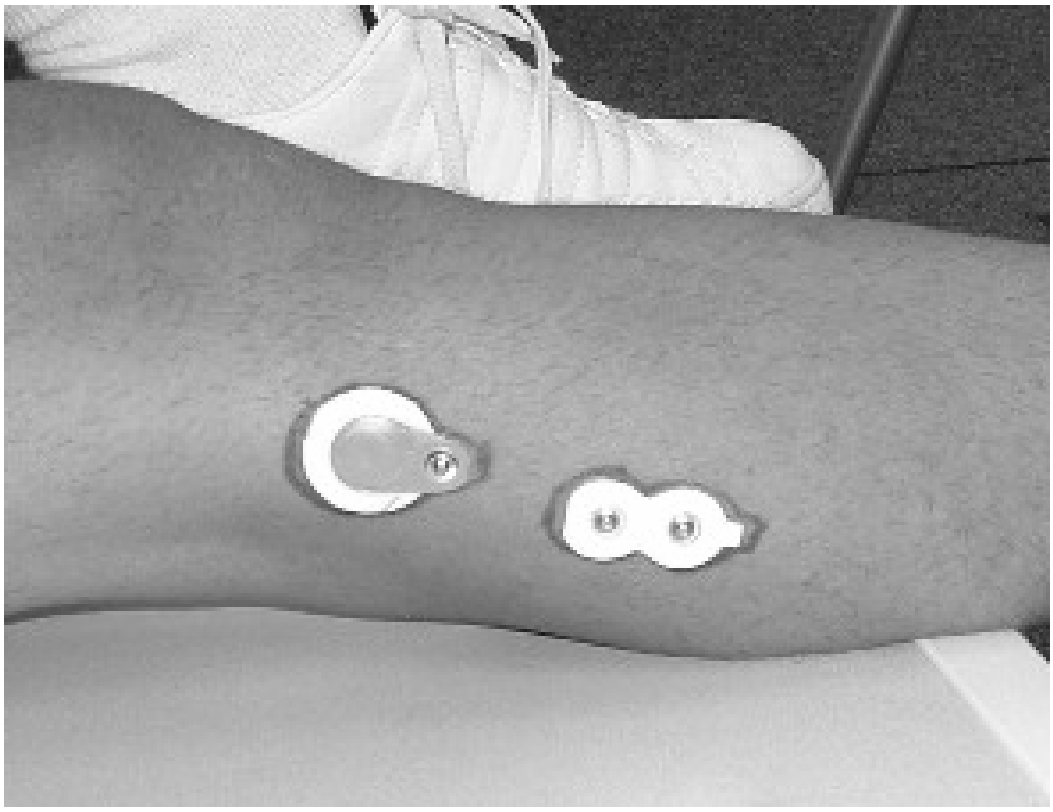

Figure 3. Dual electrodes are placed over the peroneus longus, and a single ground electrode is placed over the head of the fibula. Their positions are marked to ensure consistent placement.

Figure 4. Stretch tape is used instead of underwrap, and a single 3 inch moleskin stirrup is applied medial to lateral.

Figure 5. Two continuous heel lockk//figure -eight combinations are applied using 3 inch semi-elastic brown stretch tape.

Figure 6. The tape cast is completed by applyying heel lock s, figure- eights, and re-anchoring strips using 2 inch zinc tape.

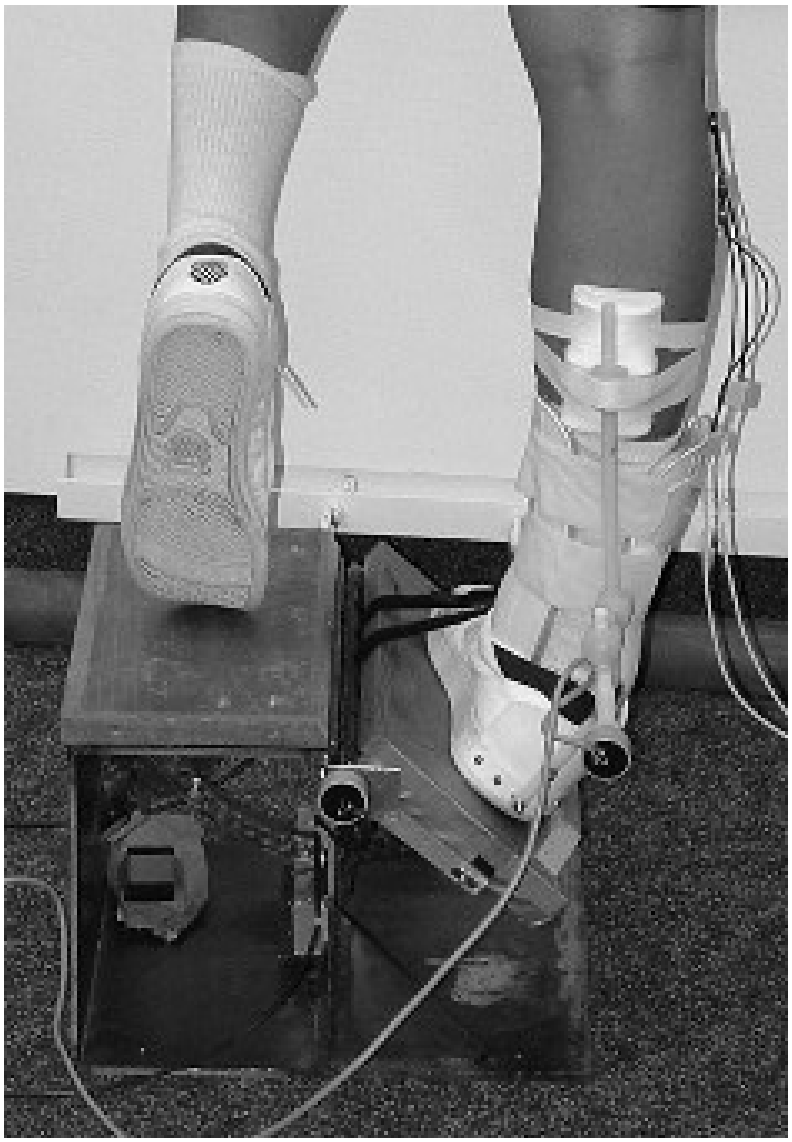

Figure 7. The platform is dropped at random intervals and the subject "rides" the platform into the resultant inversion.

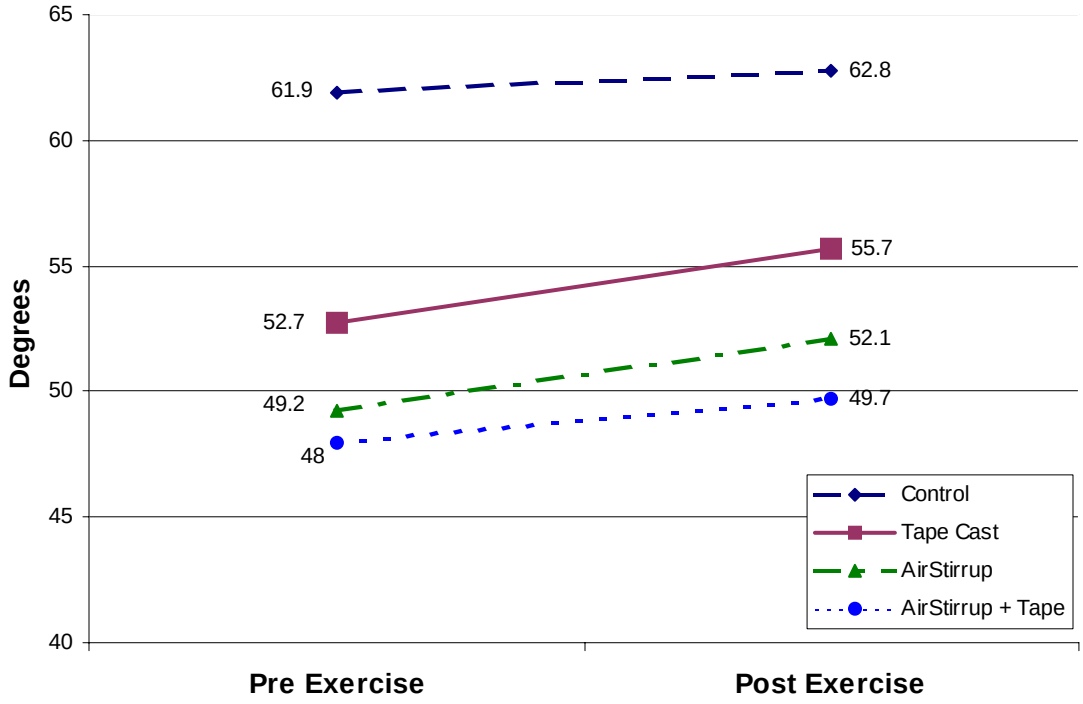

Figure 8. Total Inversion Pre to Post Exercise

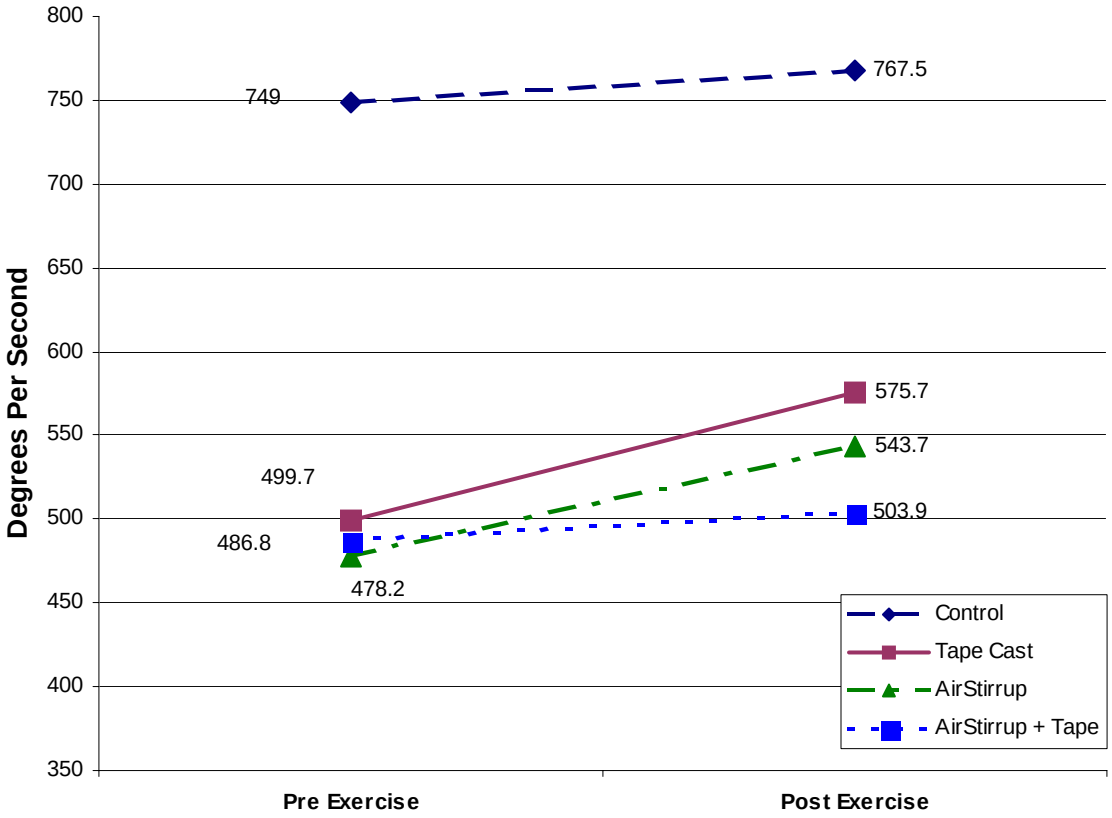

Figure 9. Maximum Inversion Velocity Pre to Post Exercise

Appendix A

Prospectus

Chapter One

Introduction

Though a primary duty of an athletic trainer is the prevention of injury, injuries do inevitably occur. It then becomes the trainer's goal to prepare the athlete for return to participation, using methods that will protect the athlete from aggravating the injury during rehabilitation, and, upon return to participation, to prevent reinjury.[1,2]

The most commonly injured joint in sports is the ankle, comprising 20-25% of all injuries associated with loss of training time.[1,3] The lateral, or inversion sprain, is the most common ankle injury.[1-8] Taping and bracing have been used both prophylactically against first time ankle injuries,[1,2] and for preventing reinjury.[1-3] A variety of braces and taping methods exist to support the ankle, including the Air-Stirrup (Aircast, Inc. Summit NJ) and a taping procedure called the "tape cast."

Problem

Both the Air-Stirrup and the tape cast may be used to provide more external support to the ankle than conventional taping alone, thus better protecting athletes who have not yet completed the repair phase of tissue healing following injury as they return to participation. Previous studies have examined the ability of the Air-Stirrup to resist ankle inversion.[7,9-12] However, a review of the literature revealed no studies examining how effective an Air-Stirrup, applied over a taped ankle, would be at resisting inversion, nor were there any studies examining how effective a tape cast, alone, would resist inversion. Also, to date there is no published information addressing comparisons between the Air-Stirrup, the Air-Stirrup applied over tape, and the tape cast with reference to their respective resistive effects on dynamic ankle inversion.

Hypotheses

A significant difference exists between the effect of no support, an Air-Stirrup air cast, Air-Stirrup air cast applied over a taped ankle, and the tape cast on total ankle inversion range of motion. A significant difference exists between the effect of these support methods on maximum inversion velocity.

Null Hypotheses

No significant difference exists between the effect of no support, an Air-Stirrup air cast, Air-Stirrup air cast applied over a taped ankle, and the tape cast on total ankle inversion range of motion. No significant difference exists between the effect of these same support methods on maximum inversion velocity.

Experimental Design

The independent variables will be the exercise bout and the methods of support: no support (control), Air-Stirrup only, Air-Stirrup applied over a taped ankle, and tape cast. The dependent variables will be total inversion (measured in degrees) and maximum inversion velocity.

Ankle Support Methods

Air-Stirrup

The Air-Stirrup, consisting of two molded sides made of hard plastic that approximate the ankle medially and laterally, fits inside a shoe. Each side is lined with a pre-inflated air cell that is adjusted to the wearer's ankle. The Air-Stirrup is also equipped with an adjustable heel pad and two Velcro straps that encircle the lower leg proximal to the malleoli.[9,11,13]

Air-Stirrup Plus Tape

Ankles will be taped in a closed basketweave fashion as described in Arnheim,[2] using 3.8 cm (1.5 in) zinc oxide tape (Jaybird & Mais, Inc. Lawrence, MA), and pretaping underwrap (Mueller Sports Medicine, Inc. Prairie du Sac, WI). Tape adherent spray (Mueller Sports Medicine) and heel and lace anti-friction pads, (Cramer Products, Inc. Gardner, KS) containing a small amount of skin lubricant (Cramer Products, Inc.), will be applied before the underwrap. A sock will be worn over the tape application and the Air-Stirrup will be worn over the sock and inside the shoe according to manufacturer's instructions.

Tape Cast

The tape cast consists of 7.6 cm (3 in) conforming Jaylastic Athletic Stretch Tape (Jaybird & Mais), 7.6 cm (3 in) Protekto Moleskin (Protekto, Jesup, GA), 7.6 cm (3 in) Jaylastic Plus II semi-elastic brown tape, and 5 cm (2 in) zinc oxide tape (Jaybird & Mais). It also includes tape adherent spray (Mueller Sports Medicine), and heel and lace anti-friction pads (Mueller Sports Medicine) containing a small amount of skin lubricant (Cramer Products, Inc.).

Assumptions

1. The subjects will give an accurate self-history.
2. The low-top shoes provided will not significantly affect the data results.
3. The calibrations of the equipment used will be accurate.

Delimitations

The subjects in this study will be active persons between the ages of 18 and 35, with no preexisting ankle injury. They will be performing exercises in a controlled setting, which may not accurately represent conditions on the playing field.

Limitations

Although the ankle will be dropped into inversion, this does not account for the plantar flexion and external rotation of the lower leg, which can accompany inversion in the mechanism of injury for most ankle sprains.[1-3,5,6,14] Some subjects may not be as able to relax as others, therefore, they will require more trials than other subjects to get acceptable data, and these additional trials could possibly affect the integrity of the particular support method being tested.

Significance

Because a previous study reported that subjects found the Air-Stirrup to be more comfortable than ankle taping,[15] and over an extended period of time a reusable brace may be less expensive than daily taping, athletic trainers may choose to use bracing to protect recently injured athletes. This study will provide information on two methods of ankle support not yet found in the literature by examining how well these support methods resist ankle inversion. This may predict how well they respectively would resist aggravation of a recent ankle injury. Therefore, not only will this study provide more support options to consider, the results may help athletic trainers decide which method to use when extra support is needed for protecting an athlete who returns to participation while in the repair phase, given both economic and functional considerations.

Chapter Two

Review of Literature

Lateral ankle sprains are one of the most common injuries in sports.[1-8] Plantar flexion, combined with inversion, is the most common mechanism of injury,[1-3,5,6] being responsible for 85% of all ankle sprains.[5,14] This prevalence of ankle injuries in sports, has prompted clinicians to develop various means of external ankle support, with the intention of protecting the ankle ligaments while allowing for normal function.[16] These efforts have led to the development of different taping techniques, soft re-useable braces, and semi-rigid plastic braces. Although research has been done comparing these three methods of ankle support,[7,12,17,18] none have included an examination of the respective ability of a tape cast to resist inversion.

Lateral Ankle Sprains

Inversion sprains are more common because there is more anatomical resistance to eversion. The deltoid ligament, on the medial side of the ankle, is stronger than the lateral ligaments[1,3,8] and there is more bony stability on the lateral ankle.[1-4,6,7,14] The lateral malleolus is longer than the medial malleolus, and thus, eversion is restricted more while greater inversion motion is allowed.[1,3,6,14]

The lateral ankle ligaments (anterior talofibular, calcaneofibular, and posterior talofibular) are arranged so that at least one of them is tight throughout the ankle range of motion.[3,8] However, strain the anterior talofibular ligament increases with inversion at all positions of ankle flexion,[19] and thus, the anterior talofibular ligament is the most commonly injured.[2,5-8]

Ligament Injury

After a ligament is injured, the first 24 to 48 hours is known as the acute inflammatory phase. During this time, vascularized tissue is involved in a series of reactions in response to the injury. These reactions serve to remove foreign debris and reduce the chance of infection so optimal healing may take place.[20] As the inflammatory phase nears its end, the injured tissue begins a fibroplastic (repair) phase. Fibroblasts migrate to the site of trauma and proliferate to produce new collagen and elastin that are used to reconstruct the connective tissue matrix.[20] The new collagen is laid down in a haphazard fashion[20,21] and the majority of new collagen is laid down by 15 to 20 days after the injury.[22] The mass of new collagen is not very strong at this point. The new scar will not be at full strength until a remodeling phase takes place, wherein the collagen fibers are arranged parallel to the lines of stress.[20,21] It may take up to a year to complete the remodeling phase.[20,21]

Motion provides an ideal stimulus for collagen regeneration. The collagen fibers will be laid down parallel to the lines of stress, decreasing remodeling time.[20] Stimulating the new collagen to form parallel to the lines of maximal stress is critical to developing a strong healed ligament.[8] Focusing on early mobility provides this type of stimulus and is crucial to achieving optimal function, as well as long term ankle stability.[8]

Functional Management

Functional management of ankle sprains (introducing and encouraging as much function as possible throughout the injury healing process) has been shown to decrease recovery time, allowing for a quicker return to activity.[21-27] Thus, early treatment of ankle injuries should be carried out on an ambulatory basis and the athlete should be allowed to

return to activity as soon as possible.[28] When treating injuries this way, protected function is the key,[26] serving to bridge the gap between early healing and a full recovery, if the functional activities are protected and initiated gradually.[13] Initially, the aim is to reduce pain and swelling and to promote dynamic function while protecting the ligaments from re-injury and allowing normal function of the uninjured structures.[23,28] Early aggressive treatment, such as this, may allow return to participation within a few days,[13] though not at full strength. Successful functional management of ankle sprains is facilitated by using external ankle support, such as tape and braces, used prophylactically as well as post-injury to provide additional joint stabilization.[1]

Closed Basketweave Taping vs. Bracing

Taping and bracing have both been shown to maximally resist movement immediately after application.[6,10,12,16,29-38] Studies examining the effects of exercise on the restrictive abilities of tape have produced a variety of results. Although one study reported that tape retains as little as 40% of its range of motion restriction after 20 minutes of exercise,[38] there have been more reports of tape retaining approximately 50%, or more, after exercise bouts of various lengths up to three hours.[6,34-36,38] While acknowledging that tape does lose restrictive ability, Wilkerson[38] suggested that, for injury prevention, limitation of motion may only be required near the limits of normal range of motion. If this is so, the loosening of the tape may not necessarily eliminate its protective effect.

When examining the comparative effects of tape and braces on functional performance (vertical jump, agility tests, sprints),[15,31] and sagittal plane movement,[17,38] both support methods have been reported to be statistically similar. However, studies

comparing tape to different types of braces, relative to their respective effects on frontal plane ankle range of motion,[7,10,12,16,17,29-33,38] yielded different results.

Two studies reported that tape has been able to resist ankle inversion more than braces immediately after application, but one of these studies used a prosthetic device in place of a human ankle,[29] and the other compared tape with braces that had no significant restrictive qualities at all.[32] Data have suggested taping and bracing provide statistically similar amounts of support after actual exercise[31,33] (vertical jump, agility tests, lateral and forward running) and simulated exercise,[29] but none of these studies tested ankles under weightbearing conditions. Martin and Harter[12] compared the effects on inversion provided by tape, lace-up bracing, and the Air-Stirrup on a treadmill tilted 8.5° in the frontal plane. They reported that the lace-up brace and the semi-rigid orthosis provided similar inversion restraint and both were superior to that provided by tape.

The results obtained when comparing the restrictive effects of tape and semi-rigid orthoses on ankle inversion were different depending on the type of orthosis used. A study using a Leighton Flexometer to measure non-weightbearing active inversion, allowed by a custom made thermoplastic Surlyn brace, reported the restrictive effects of the brace to be similar to restriction provided by tape immediately after application and following 20 minutes of exercise.[30] The Ankle Ligament Protector (Donjoy Orthopedic, Carlsbad, CA) was similar to tape before exercise, but retained more restrictive abilities than tape after 20 minutes, one hour, and three hours of volleyball practice.[16]

Air-Stirrup

The Air-Stirrup has been reported to provide better resistance to inversion than tape immediately after application and after approximately 15 minutes of exercise.[10] The

Air-Stirrup has been used prophylactically and post injury.[8] Stover[13] introduced the Air-Stirrup as a means to provide stability while allowing some function for acute ankle ligament injuries, stable malleolar fractures, and posterior tibialis tendinitis. The inflatable air cells allow ambulation with both compression and protection, while at the same time allowing motion in a range that is safe for the injured ligaments.[8] Use of the Air-Stirrup in this way reportedly reduces recovery time, thus facilitating an earlier return to activity than immobilization.[22,23,26,27] It has also been reported that use of the Air-Stirrup reduces the incidence of ankle injuries.[9,40]

Studies examining restrictive qualities of the Air-Stirrup report that it is able to significantly resist inversion.[7,9-12] One study used an inversion platform and frame-by-frame film analyses to measure inversion. Subjects wearing no support had a mean inversion of 29.2°, while those wearing an Air-Stirrup had a mean inversion of 19.4°. Thus the Air-Stirrup reduced inversion by 9.8°.[11] When compared with the Kallassy Ankle Support (Sports Supports, Dallas, TX), the Ankle Ligament Protector (Donjoy Orthopedics, Carlsbad, CA), and the Swede-O Universal Ankle Support (Swede-O Universal, North Branch, MN), the Air-Stirrup was reported to better resist ankle inversion immediately after application and after ten minutes of exercise.[39]

One study examining motor performance compared the Air-Stirrup to adhesive ankle taping.[15] The authors reported that neither the brace nor the taping significantly affected agility, speed, or vertical jump, and that subjects reported the Air Stirrup was more comfortable to wear.

Tape Cast

The tape cast is a taping procedure which utilizes moleskin and semi-elastic tape in addition to standard zinc oxide tape. The purpose of the tape cast is to protect injured ankle ligaments while allowing athletes to participate in their respective sports activities before complete healing of the ligament has occurred. The perceived need for extra protection has prompted athletic trainers to use different types of tape to enhance the support provided by the standard closed basketweave. The tape cast used in this study has evolved through experience and experimentation over time, and is taught to student athletic trainers at Brigham Young University. While no literature exists discussing the tape cast as described here, studies have been conducted which have investigated components of the tape cast, used in conjunction with zinc oxide tape, to examine if they significantly enhance ankle support.[31,38,39] A moleskin stirrup, used in one taping procedure, was reported to allow functional range of motion as well as the Air-Stirrup did, but this study did not examine its effects on inversion.[39] A three-tailed moleskin stirrup applied over a conventional tape application provided a degree of support similar to that provided by the Swede-O brace after 20 minutes of exercise.[31] A taping procedure utilizing semi-elastic tape in addition to conventional taping provided more inversion restriction before and after a two to three hour football practice session than the conventional method alone.[38] In addition, the percentage of restriction retained by the modified method, after exercise, was nearly twice that of the conventional method.

Equipment

Platforms with a trapdoor that rotates in the frontal plane (inversion platforms) are used in an attempt to better replicate the dynamic inversion component of a lateral ankle sprain. They have been used to take measurements at 30° [4,42,43] and 35° [11,35,44,45] of ankle inversion. Ricard et al[36] set the maximum angle of inversion at 37° and added a 15° plantar flexion component.

Frame-by-frame film analyses have been used in conjunction with inversion platforms to determine total inversion, time to total inversion, and rate of inversion.[4,11,35,43,45] Rather than use video analyses, Ricard et al[36] used electronic goniometers to obtain more accurate measurements of inversion and rate of inversion. They chose to use the electrogoniometer, instead of the video technique they had used in other studies, because the goniometer had an increased sampling rate (1000 Hz compared to 60-120 Hz with video). They suggested that 60 to 120 Hz was not fast enough to capture the dynamic nature of ankle inversion.

Summary

The Air-Stirrup has been shown to resist ankle inversion more than conventional taping.[7,10,12] While studies exist comparing different taping methods with the AirStirrup,[7,10,15,17,18,39] no literature currently exists comparing the ability of an Air-Stirrup to resist sudden weightbearing ankle inversion to the ability of a taping procedure incorporating both moleskin and semi-elastic tape, such as the tape cast, to resist the same. In addition, no literature currently exists which examines the effects of an Air-Stirrup applied over a taped ankle on sudden weightbearing ankle inversion. This study will determine which of the tested support methods, if any, is most effective at resisting

dynamic ankle inversion immediately after application, and after 25 minutes of moderate exercise. The purpose of this study is to compare the effects of no support, an Air-Stirrup, an Air-Stirrup applied over a taped ankle, and a tape cast before and after exercise on dynamic inversion of the ankle.

Chapter Three

Methods

Subjects

Sixteen subjects between the ages of 18 and 35 years with no history of ankle injury within six months prior to their participation, and no acute symptoms of lower leg, ankle, or foot injury, will be used for this study. Subjects will be excluded if they exhibit a painful gait or a painful range of motion. Subjects will be dropped from the study if they incur any injury to the lower leg, foot, or ankle during the time they are participating in the study.

After being informed of their rights as subjects, and of the possible risks of participating, they will be asked to give written informed consent before they will be allowed to participate, and the project will have university human subjects board approval. Subjects will also be asked to read and answer the questions on the Physical Activities Readiness Questionnaire[46] form prior to participating. Subjects answering any question indicating that participation in this study would present a health risk to them, will not be allowed to participate.

In order to familiarize subjects with the testing process, the procedures will be explained and demonstrated, and the subjects will be allowed ten practice trials on the inversion platform within one week before they perform their trials for data collection. Subjects will wear the same K-Swiss (Westlake Village, CA) Lozan low-top athletic shoes, which will be provided, for all testing sessions.

Instruments

The inversion platform used in this study will be equipped with a hand-held button which is electronically attached to a magnetic release mechanism on the trap door of the platform. When the release mechanism is activated, the foot-support base of the platform will rotate 37° on the anterior-posterior axis (frontal plane) creating a dynamic inversion force on the ankle. The inversion platform used will be similar in design and function to inversion platforms used in other studies.[4,11,35,36,42-45]

An electrogoniometer will be used to measure ankle inversion rather than using video marker tracking. The electrogoniometer will be attached to the heel of the subject's shoe and to the base of the gastrocnemius in line with the Achilles tendon, and its position will be outlined with a marker for future reference. This electrogoniometer will measure the inversion of the subjects ankle as a function of time. Ricard et al established the validity of this electrogoniometer in a previous study.[36] Due to the fragile nature of the instrumentation, and the potential that the exercise bout would alter the position of the goniometer, the goniometer will be removed for exercise and then replaced using the marker guidelines. Another electrogoniometer will be placed on the platform, from the base support to the trap door, to measure the rate and distance and time of the trap door fall.

Surface electromyography (EMG) will be used to record the level of activity of the peroneus longus and the tibialis anterior to assure that there is no muscle contraction prior to activation of the trap door. A quiet signal (i.e.: no muscle activity) will be obtained before the trap door is activated. EMG and goniometer signals will be sampled at 1000 Hz using a Micron P-133 computer interfaced to a Noraxon (Scottsdale, AZ)

EMG amplifier by a Keithley-Metrabyte (Taunton, MA) 1802 HC, 64-channel, 12-bit analog-to-digital converter. The EMG signals will be recorded with Noraxon bipolar Ag/AgCl surface electrodes (Noraxon Dual Electrode, Product #272). The EMG signals will be differentially amplified with a gain of 1000 and a bandwidth of 16-500 Hz at -3dB using a Noraxon Telemyo telemetry system. The Noraxon amplifiers have an input noise below 1 μV RMS and an effective common mode rejection ratio of 135 dB.

Procedures

The subject's gender, height, and weight as well as a previous history of injury will be recorded. All EMG electrodes and ankle support methods will be applied to the right leg.

The electrode sites will be prepared by shaving the hair, lightly abrading the skin with a gauze pad and cleansing the area with rubbing alcohol to lower input impedance below 3000 Ω. Electrodes will then be centered over the approximate middle of the muscle bellies of the tibialis anterior and peroneus longus muscles, respectively. The electrodes will be placed in a vertical fashion, in pairs 2 cm apart from center to center. A ground electrode will be placed directly over the head of the right fibula. The electrode positions will then be marked with a permanent marker for accurate repositioning in future trials. The marks will be re-established at the conclusion of each testing session, and subjects will be instructed to re-establish them, if needed, after bathing. The goniometer and electrode placement marks are not to be removed until their participation in the study has ended.

Once the electrodes are in place, the subject's right ankle will be fitted with the support method they will be testing that day. Each subject will be tested under all four conditions: no tape (control), Air-Stirrup only (brace), Air-Stirrup with the ankle taped underneath (brace/tape), and tape cast. The treatment order will be randomly assigned using a balanced Latin square. The testing of each condition will take place on separate days, which will be specified upon completion of the first testing session. Testing sessions will be no less than two days apart, and all testing sessions for each subject will be completed within a three week period. The primary investigator will place the electrodes for each subject and conduct all testing sessions.

In addition, the primary investigator, a certified athletic trainer, will apply each tape application to each subject. Under the control condition, the subject will be tested wearing only socks and tightly laced low-top athletic shoes. When testing the brace condition, the subject will wear the Air-Stirrup over their sock, but inside a tightly laced shoe, according to product instructions. Under the brace/tape condition, the subject will have the right ankle taped with 3.8 cm (1.5 in) zinc oxide tape (Jaybird & Mais, Inc. Lawrence, MA), pretaping underwrap (Mueller Sports Medicine, Inc. Prairie du Sac, WI), heel and lace anti-friction pads (Cramer Products, Inc. Gardner, KS), which will contain a small amount of skin lubricant (Cramer Products, Inc. Gardner, KS), and tape adherent spray (Mueller Sports Medicine).

Before application of the tape, the Air-Stirrup will be applied and a line will be traced onto the leg along the top of the Air-Stirrup, marking its height for future reference. After removing the Air-Stirrup, tape adherent will be sprayed over the entire area to be taped and allowed to dry a few seconds. The lubricated heel and lace pads will

then be placed directly over the Achilles tendon and anterior ankle. With the subject's foot at a 90° angle to the lower leg (neutral), underwrap will be applied starting at approximately the base of the fifth metatarsal and wrapping around circumferentially up the ankle and leg, ending approximately 2.5 cm below the reference mark and overlapping half of the underlying strip. Tape anchors will be placed circumferentially around the leg with the top anchor starting at the reference mark, and the other anchor placed just posterior to the base of the fifth metatarsal. Taping will then proceed in a closed basketweave fashion, as described in Arnheim.[2] The sock will be worn over the tape, with the brace being worn over the sock and inside the tightly laced shoe.

The tape cast consists of 7.6 cm (3 in) conforming Jaylastic Athletic Stretch Tape (Jaybird & Mais), 7.6 cm (3 in) Protekto Moleskin (Protekto, Jesup, GA), 7.6 cm (3 in) Jaylastic Plus II semi-elastic brown stretch tape, and 5 cm (2 in) zinc oxide tape (Jaybird & Mais), with heel and lace pads and adherent spray as discussed above. The tape cast will be applied with the foot of the subject in the neutral position. The spray and pads will be applied in the same manner as with the other taping treatment, followed by the conforming Jaylastic Athletic Stretch Tape to be applied in the same manner as the underwrap. A single moleskin stirrup will then be applied medial to lateral, after which taping will proceed with the zinc oxide tape in the same manner as the closed basketweave. However, two continuous heel lock/figure eight combinations will be applied with the Jaylastic Plus II stretch tape before the heel locks are applied with the zinc oxide tape. The tape cast will be completed by applying 5 cm zinc oxide heel locks, figure eights, and re-anchoring strips, as done with the closed basketweave. A sock will be worn over the tape cast and the shoe will be worn, tightly laced, over the sock.

Once the subject is fitted with a method of support, pretesting, exercise, post-testing will commence. During pretesting and post-testing, the goniometer will be attached to the rear of the subject's shoe and to the base of the gastrocnemius in line with the Achilles tendon. Each time the goniometer is attached, it will be zeroed with the subject's right ankle in their "normal" weightbearing position. This should eliminate any errors that may occur due to the removal and replacement of the goniometer before and after exercise respectively. The platform goniometer will also be zeroed before each set of trials and the EMG electrodes will be attached to the telemetry system.

During pre and post exercise inversion testing, the subject's right foot will be strapped tightly against the side bar on the surface of the platform using a hook and loop fastener strap to prevent the subject's foot from sliding across the surface of the platform. The subject will stand facing away from the testers to avoid anticipation of the platform drop, and will be instructed to stand with the weight on the right foot, using the left great toe for balance, until the platform drops. The platform will drop at random intervals and the subject will be instructed to "ride" the platform into the resultant inversion that occurs (i.e., do not attempt to stop the motion by activating the muscles). Trials will only be recorded and saved for analysis if there is no EMG evidence of preactivation of the muscles and no delay between the platform drop and foot inversion. The subject will be repeatedly dropped into inversion until five acceptable trials are recorded.

The exercise bout will consist of a five minute warm-up treadmill run at or near 8.05 kph (5 mph), depending on the endurance of the subject. Following the treadmill exercise, the subject will participate in an exercise bout designed to stress the support methods in a way similar to what would be experienced if they were used by an athlete

in-season. The exercises will be performed on a regulation size basketball court and will be as follows:

1. Three sets of seven 15.4 m (50 ft) shuttle runs (seven times across the width of the court) in 30 seconds or less, with 90 seconds rest between sets.
2. Three sets of 15 3.7 m (12 ft) lateral slide shuttles (back and forth across the width of the key) in 20 seconds or less, with 60 seconds rest between sets.
3. Six sets of 28.9 m (94 ft) "combination sprints" in eight seconds or less, with 25 seconds rest between sets. Three sets will be performed with the subject starting on the baseline, sprinting forward 14.5 m (47 ft) to halfcourt, turning around and backpedaling the remaining distance to the opposite baseline. The other three sets will be opposite; backpedal to halfcourt, turn and sprint forward the remaining distance to the opposite baseline. This is designed to stress the ankle in plantar/dorsiflexion as well as internal/external rotation
4. Three sets of 15 vertical jumps off two feet in 15 seconds or less, with 45 seconds rest between sets. The subjects will be instructed to attempt to touch the backboard of a basketball standard with each hop.

The subject will be allowed two minutes rest between exercises, and the entire exercise bout, including the treadmill warm-up, will last approximately 25 minutes.

Following the exercise bout, the subject will be post tested using the same procedures as the pretest. At the conclusion of the post test, the goniometer and electrodes will be removed and their positions will be re-marked to ensure consistent replacement. The subject will then be asked to return for the next testing condition, at a specified time, no less than two days, and no more than four days later.

Data Analysis

EMG signals will be converted from analog to digital by a Keithley-Metrabyte (Taunton, MA) 1802 HC, 64-channel, 12-bit analog-to-digital converter, yielding measurements of total inversion, time to maximum inversion, and maximum inversion velocity. Total inversion will be defined as the difference between initial joint angle (prior to dropping the inversion platform) and the maximum inversion point reached following platform drop. The time to maximum inversion will be defined as the difference in time from the initiation of platform drop to the time at which the ankle was maximally inverted. The maximum inversion velocity will be defined as the greatest velocity obtained between platform drop and the maximum inversion point.

Design and Statistical Analysis

This study will use a repeated measures design. Multivariate analyses of variance (MANOVAs) will be used to compare the support conditions on the five trials for the two dependent variables: total inversion and maximum inversion velocity. Post hoc tests of significant multivariate statistics will be performed. Alpha will be set at .05 for all comparisons.

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Appendix B

Additional Methods

Table B1. Informed Consent Form_____

CONSENT TO BE A RESEARCH SUBJECT

The purpose of this study is to compare the restrictive effects of an Air-Stirrup alone, an Air-Stirrup over a taped ankle, and a tape cast. It is being conducted by Justin Freeman, a graduate student in the Physical Education Department at Brigham Young University.

You will be asked to make four visits to the Human Performance Lab in the Richards Building within a three week period. It will take approximately one hour per visit to complete testing. Four different conditions will be tested: no support, Air-Stirrup, Air-Stirrup plus tape, and the tape cast. The procedure used throughout this study will involve application of the condition being tested to the right ankle, an exercise bout of approximately 25 minutes, and a test on an inversion platform before and after the exercise.

The exercise bout will include a five minute treadmill run at 5 mph, followed by these exercises:

1. Three sets of seven 15.4 m (50 ft) shuttle runs (seven times across the width of a basketball court) in 30 seconds or less, with 90 seconds rest between sets.
2. Three sets of 15 3.7 m (12 ft) lateral slide shuttles (back and forth across the width of the key) in 20 seconds or less, with 60 seconds rest between sets.
3. Six sets of 28.9 m (94 ft) "combination sprints" in eight seconds or less, with 25 seconds rest between sets. Three sets will be performed starting on the baseline, sprinting forward 14.5 m (47 ft) to halfcourt, turning around and backpedaling the remaining distance to the opposite baseline. The other three sets will be opposite; backpedal to halfcourt, turn and sprint forward the remaining distance to the opposite baseline.
4. Three sets of 15 vertical jumps off two feet in 15 seconds or less, with 45 seconds rest between sets. The subjects will be instructed to attempt to touch the backboard of a basketball standard with each hop.

You will be required to stand on a platform which will give way and cause your ankle to roll somewhat. The amount of roll, however, will be strictly controlled to limit the potential for injury. The platform used in this study will be equipped with a hand-held button which is electronically attached to a magnetic release mechanism on the trap door of the platform. When the release mechanism is activated, the base of the platform will drop 37°. Although the design of the platform is such that it attempts to simulate what happens during an ankle sprain, the platform will not allow your ankle to move far enough to cause an actual ankle sprain.

As participation in this study requires maximal effort when performing the exercise routine, inclusion in this study does involve risk. As mentioned above, the risk of ankle sprain on the inversion platform will be minimized by setting the trap door so that the ankle cannot roll far enough to be sprained. There is a risk of post exercise muscle soreness, however, if you already exercise regularly this will probably not occur. There is also a small risk for musculoskeletal injuries including sprains and/or strains to the lower limb from the exercise protocol. However, the warm-up on the treadmill is included for the purpose of decreasing your risk of muscle strain during the exercise bout. You will perform all exercises by yourself so that there is no risk of experiencing a sprain as a result of contact with other people.

Although the risk of injury is minimal, should you incur any injury as a direct result of your participation in this study, a certified athletic trainer will be on hand for immediate injury management. If any further treatment is required, you will be referred to the Health Center, and you will be asked to have your insurance cover the cost.

As with all exercise, there is an extremely minimal risk of heart attack, stroke, or even death. To further minimize the risk, screening for potential cardiovascular risk factors will be done by asking you to complete a Physical Activities Readiness Questionnaire, which examines your general health. If any of your answers suggest that your participation in this study might present a health risk to you, you will not be allowed to participate.

Participation in this study is voluntary and provides no individual benefits. However, it may help sports medicine clinicians to better protect the ankle after recent injury. The results of the testing will be reported as a group, and therefore, your individual results will remain confidential. You may withdraw from this study at any time without adverse consequences to yourself.

If you have any questions regarding your rights as a participant in this study you may contact:

Dr. Shane Schulthies, Chair of the Institutional Review Board, 120-B RB, Brigham Young University; phone 378-5490.

If you have any questions regarding any aspect of this study you may contact:

Justin Freeman, 270 SFH, BYU; phone 371-8620 or
Dr. Bill Myrer, 120-G RB, BYU; phone 378-2690.

By signing below, you declare the following:

1. That you have read and understand this consent form.
2. That you desire, according to your own free will and volition, to participate in this study.
3. That you accept the risks relating to this study.

_____

Signature Date

_____

Name (please print)

Table B2. Physical Activity Readiness Questionnaire (PAR-Q)

Physical Activity Readiness Questionnaire - PAR-Q (revised 1994)

PAR - Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO	
☐	☐	1. Has you doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
☐	☐	2. Do you feel pain in your chest when you do physical activity?
☐	☐	3. In the past month, have you had chest pain when you were not doing physical activity?
☐	☐	4. Do you lose your balance because of dizziness or do you ever lose consciousness?
☐	☐	5. Do you have a bone or joint problem that could be made worse by a change in your physical activity?
☐	☐	6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
☐	☐	7. Do you know of any other reason why you should not do physical activity?

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want—as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active—begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal—this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever—wait until you feel better; or
- if you are or may be pregnant—talk to your doctor before you start becoming more active.

Please note: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

You are encouraged to copy the PAR-Q but only if you use the entire form

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction.

NAME _____

SIGNATURE _____ DATE _____

SIGNATURE OF PARENT or GUARDIAN (for participants under the age of majority) _____ WITNESS _____

Supported by: Health Canada Santé Canada

Appendix C

Additional Results

Table C1. Raw Data

Condition 1 = Control pre exercise
Condition 2 = Tape Cast pre exercise,
Condition 3 = Air-Stirrup pre exercise
Condition 4 = Tape/Brace pre exercise
Condition 5 = Control post exercise
Condition 6 = Tape Cast post exercise,
Condition 7 = Air-Stirrup post exercise
Condition 8 = Tape/Brace post exercise

SUBJ.	COND.	TRIAL	**TOT.INV.**	**MAX. INV. VEL.**	platform amnt.	platform rate	platform time	latency
1	3	1	-51.67782	-475.0371	39.51	383.66	103	97
1	3	2	-54.94836	-507.8931	25.14	483.62	52	117
1	3	3	-56.74915	-578.6023	39.51	355.96	111	98
1	3	4	-48.42269	-487.0472	39.86	324.13	123	123
1	3	5	-47.52157	-510.5887	40.07	315.53	127	97
1	7	1	-39.70716	-634.6788	34.54	523.47	66	126
1	7	2	-55.45974	-538.1946	39.44	323.31	122	79
1	7	3	-51.13467	-500.1884	40.14	306.45	131	110
1	7	4	-50.97461	-502.3365	40.14	282.72	142	102
1	7	5	-55.84507	-786.1786	40.27	307.41	131	124
2	1	1	-70.22176	-607.2964	23.47	451.51	52	99
2	1	2	-69.07114	-615.5948	39.56	399.64	99	96
2	1	3	-70.71729	-968.6794	39.08	454.52	86	61
2	1	4	-69.73299	-828.8803	38.61	470.93	82	72
2	1	5	-70.21442	-654.4571	39.29	427.11	92	92
2	5	1	-49.72593	-457.861	39.98	319.85	125	83
2	5	2	-51.80993	-569.6382	39.95	341.53	117	89
2	5	3	-52.73326	-561.5511	40.2	311.69	129	80
2	5	4	-48.30901	-505.1627	39.99	312.49	128	84
2	5	5	-52.92682	-536.7947	40.06	333.83	120	83
3	4	1	-71.66768	-838.9006	39.07	379.34	103	38
3	4	2	-65.41092	-707.3994	37.09	515.24	72	23
3	4	3	-65.83724	-602.9992	39.4	342.61	115	26
3	4	4	-68.27472	-738.0743	39.22	426.39	92	28
3	4	5	-69.41418	-950.6788	39.19	450.46	87	34
3	8	1	-56.73657	-618.155	39.78	212.77	187	115
3	8	2	-56.8534	-588.2216	39.35	382.08	103	95
3	8	3	-57.42189	-615.7131	39.53	324.07	122	35
3	8	4	-55.7053	-682.7335	39.92	307.14	130	128
3	8	5	-58.47321	-607.0242	39.47	375.92	105	31
5	3	1	-47.89189	-499.6586	21	403.96	52	84
5	3	2	-45.83398	-337.9178	36.42	492.21	74	94
5	3	3	-48.22535	-387.9128	39.31	333.17	118	87
5	3	4	-50.98896	-454.1426	26.71	513.71	52	97
5	3	5	-52.88776	-579.8702	40.17	299.81	134	80

5	7	1	-56.69093	-610.3449	25.57	491.77	52	124
5	7	2	-54.50841	-630.0783	22.13	425.66	52	105
5	7	3	-56.4884	-538.9209	39.75	342.71	116	124
5	7	4	-53.35648	-595.315	23.15	445.21	52	102
5	7	5	-53.04041	-526.0591	39.2	369.82	106	98
4	2	1	-48.01073	-512.0449	37.06	553.2	67	46
4	2	2	-48.53839	-542.4376	39.75	334.09	119	44
4	2	3	-51.54697	-585.5007	39.34	351.29	112	46
4	2	4	-44.84602	-437.3026	40.26	281.57	143	143
4	2	5	-53.33751	-572.1941	39.97	283.48	141	141
4	6	1	-65.15957	-745.6999	27.11	521.51	52	100
4	6	2	-60.05075	-687.2291	25.49	480.98	53	101
4	6	3	-58.33512	-726.9545	27.88	536.33	52	2823
4	6	4	-57.5446	-683.9104	29.02	558.14	52	103
4	6	5	-59.75147	-767.9196	29.11	559.85	52	83
6	1	1	-60.64392	-468.0367	22.6	434.79	52	87
6	1	2	-60.87364	-520.1807	24.04	462.31	52	102
6	1	3	-56.91793	-537.2333	39.88	295.43	135	87
6	1	4	-62.01632	-584.3587	17.58	338.21	52	102
6	1	5	-60.24608	-598.3582	20.03	385.26	52	79
6	5	1	-59.41536	-646.717	21.79	419.2	52	110
6	5	2	-65.12103	-777.1063	39.25	344.31	114	87
6	5	3	-60.71377	-699.4486	24.73	475.67	52	106
6	5	4	-66.7384	-763.957	23.43	450.69	52	101
6	5	5	-66.14294	-793.1185	20.58	395.93	52	82
7	4	1	-54.28373	-433.8417	39.76	364.77	109	93
7	4	2	-48.81792	-496.9606	23.44	450.83	52	45
7	4	3	-53.70832	-588.1214	39.71	367.7	108	72
7	4	4	-51.96542	-586.5555	39.9	344.04	116	36
7	4	5	-50.57721	-520.37	39.66	354.18	112	137
7	8	1	-61.96252	-516.9844	39.79	368.45	108	38
7	8	2	-49.66751	-501.9608	40.08	351.59	114	91
7	8	3	-51.96172	-511.3607	39.77	348.87	114	139
7	8	4	-49.3148	-619.257	24.49	471.09	52	120
7	8	5	-51.85691	-665.9558	39.26	373.98	105	80
8	2	1	-40.7913	-456.6488	39.73	274.01	145	78
8	2	2	-45.93477	-386.1141	39.95	254.48	157	72
8	2	3	-55.86605	-510.7269	40.12	280.61	143	47
8	2	4	-55.12694	-470.8729	40.1	290.6	138	43
8	2	5	-53.54161	-430.3007	40.58	253.66	160	43
8	6	1	-63.31873	-538.3725	39.98	338.81	118	77
8	6	2	-52.43584	-509.6073	40.15	291	138	79
8	6	3	-57.53581	-578.475	40.18	297.66	135	78
8	6	4	-61.68037	-568.3217	20.37	391.83	52	49
8	6	5	-62.17128	-599.1726	39.23	435.89	90	71
9	3	1	-54.86466	-550.1194	39.79	410.26	97	109

9	3	2	-46.5633	-345.6478	23.65	454.86	52	106
9	3	3	-51.43481	-421.6852	25.28	486.23	52	103
9	3	4	-51.53476	-418.9644	24.33	468.02	52	84
9	3	5	-50.15784	-477.334	28.15	541.44	52	126
9	7	1	-55.531	-577.9457	20.94	402.85	52	78
9	7	2	-55.73485	-473.8169	21.9	421.34	52	77
9	7	3	-52.83946	-475.07	25.17	484.03	52	71
9	7	4	-56.43187	-466.4192	24.68	474.66	52	83
9	7	5	-57.20461	-653.9783	39.47	398.73	99	97
10	1	1	-66.06691	-656.6601	30.72	404.22	76	93
10	1	2	-69.8576	-650.5184	39.53	346.83	114	93
10	1	3	-56.82456	-522.7146	40.17	273.29	147	93
10	1	4	-54.97095	-521.2574	39.41	325.73	121	95
10	1	5	-58.30392	-562.2101	39.73	342.5	116	94
11	4	1	-42.91983	-432.2415	39.98	261.34	153	146
11	4	2	-41.70161	-413.8403	39.93	271.64	147	2444
11	4	3	-45.48614	-509.0275	40.11	313.39	128	648
11	4	4	-42.22448	-384.2964	40.04	296.61	135	2337
11	4	5	-43.42253	-473.7158	39.89	353.06	113	1964
10	5	1	-65.94615	-672.7183	38.84	373.49	104	2738
10	5	2	-65.13638	-624.8541	19.19	369.21	52	74
10	5	3	-59.81139	-622.3907	39.62	312.01	127	73
10	5	4	-62.11958	-599.8282	39.28	370.61	106	76
10	5	5	-57.96631	-595.8605	40.35	282.19	143	82
11	8	1	-35.38128	-464.2425	39.9	319.25	125	131
11	8	2	-48.00142	-357.7423	40.02	181.92	220	155
11	8	3	-46.0796	-429.5941	39.99	240.95	166	137
11	8	4	-43.98124	-363.2178	39.9	260.8	153	131
11	8	5	-42.59004	-382.1626	40.3	244.25	165	129
6	3	1	-48.69921	-480.2718	40.2	337.89	119	82
6	3	2	-50.42662	-569.0021	39.66	351.04	113	88
6	3	3	-47.46833	-461.401	39.76	320.65	124	107
6	3	4	-45.42299	-460.8707	39.58	314.16	126	113
6	3	5	-42.85209	-410.327	39.77	334.25	119	89
6	7	1	-48.84242	-549.0417	21.51	413.71	52	90
6	7	2	-50.05525	-512.9376	39.98	307.6	130	2062
6	7	3	-52.45907	-492.0921	39.88	304.46	131	90
6	7	4	-54.32637	-564.806	37.04	416.19	89	74
6	7	5	-53.00895	-524.2424	39.93	314.45	127	82
1	4	1	-44.57168	-367.5871	39.74	345.62	115	83
1	4	2	-42.32275	-438.0302	39.52	359.34	110	92
1	4	3	-44.52879	-421.3295	39.28	417.93	94	1995
1	4	4	-44.35463	-349.8445	39.64	360.39	110	1888
1	4	5	-43.33615	-413.8813	39.55	338.09	117	96
1	8	1	-50.32516	-479.9585	20.94	402.82	52	2583
1	8	2	-54.30302	-527.2327	23.75	456.73	52	75

1	8	3	-45.38054	-431.1924	39.89	349.97	114	1573
1	8	4	-52.1565	-500.9346	29.17	463.11	63	93
1	8	5	-51.04576	-551.6586	39.14	444.77	88	88
2	2	1	-47.46952	-362.8282	38.82	436.19	89	81
2	2	2	-62.69328	-422.6351	39.87	369.25	108	90
2	2	3	-61.08229	-511.6186	32.12	428.32	75	102
2	2	4	-59.45502	-453.2356	36.73	453.53	81	77
2	2	5	-60.41018	-526.083	36.42	423.54	86	95
5	1	1	-48.47495	-664.0101	23.11	444.49	52	1762
5	1	2	-60.06769	-885.5944	21	403.89	52	108
5	1	3	-59.28131	-876.8196	39.23	335.31	117	1436
5	1	4	-64.67706	-953.4492	37.46	486.5	77	1903
5	1	5	-51.93613	-950.6607	23.53	452.61	52	3033
2	6	1	-62.97717	-529.6478	20.37	391.92	52	88
2	6	2	-55.34124	-563.7283	19.69	378.74	52	89
2	6	3	-57.50208	-578.4207	18.13	348.75	52	34
2	6	4	-62.51912	-548.6107	40.06	351.45	114	153
2	6	5	-60.91392	-499.527	21.02	375.47	56	33
5	5	1	-71.80957	-868.8936	21.85	420.28	52	98
5	5	2	-67.82151	-846.2582	25.36	487.79	52	97
5	5	3	-70.47378	-979.64	24.2	465.5	52	93
5	5	4	-70.95532	-980.7368	24.11	463.8	52	90
5	5	5	-71.71979	-902.7157	21.24	408.47	52	79
4	3	1	-52.86066	-500.0315	38.77	461.6	84	1972
4	3	2	-51.39376	-528.2402	39.73	325.67	122	1880
4	3	3	-49.54859	-425.8013	27.2	523.15	52	2066
4	3	4	-52.3997	-583.0498	37.14	530.63	70	1737
4	3	5	-47.85613	-494.3371	39.62	350.66	113	1697
12	2	1	-56.54144	-561.7924	40.26	264.88	152	109
12	2	2	-57.79573	-524.519	40.44	81.53	496	50
12	2	3	-57.81651	-597.3377	23.46	360.97	65	52
12	2	4	-60.90065	-573.8306	40.31	285.94	141	50
12	2	5	-57.68032	-480.8063	19.14	368.17	52	54
4	7	1	-57.82712	-623.7908	38.05	447.65	85	28
4	7	2	-53.62049	-596.4012	38.9	442.12	88	27
4	7	3	-57.66265	-652.7281	39.15	435.1	90	25
4	7	4	-53.72714	-641.7689	39.76	313.09	127	28
4	7	5	-55.43305	-694.5038	39.64	335.93	118	26
12	6	1	-54.52087	-556.8022	40.09	308.45	130	81
12	6	2	-56.02899	-540.4978	20.88	401.55	52	118
12	6	3	-56.13757	-536.1071	19.72	379.35	52	101
12	6	4	-56.80413	-566.515	40.05	301.18	133	102
12	6	5	-54.39049	-565.8264	40.46	306.57	132	108
8	1	1	-61.48025	-794.6329	40.1	290.59	138	73
8	1	2	-57.15765	-712.5101	40.07	245.87	163	74
8	1	3	-56.59582	-723.897	40.26	268.43	150	71

8	1	4	-47.84889	-656.0535	40.02	287.98	139	75
8	1	5	-58.49883	-853.9362	39.68	305.24	130	65
8	5	1	-58.47961	-823.782	39.73	308	129	47
8	5	2	-65.49899	-878.6592	20.28	390.07	52	44
8	5	3	-65.65367	-797.9279	18.53	356.48	52	74
8	5	4	-63.29665	-708.726	19.34	372.05	52	81
8	5	5	-62.14775	-758.7375	19.33	371.88	52	52
3	1	1	-66.46957	-767.3492	29.09	409.72	71	121
3	1	2	-64.1305	-672.1897	30.31	426.97	71	77
3	1	3	-63.89082	-870.43	19.99	384.51	52	195
3	1	4	-62.3058	-777.3018	39.97	305.13	131	191
3	1	5	-62.92494	-794.5824	20.97	403.31	52	77
3	5	1	-63.71423	-710.1059	39.4	358.18	110	92
3	5	2	-64.05649	-743.4111	21.15	406.77	52	160
3	5	3	-61.84243	-661.7031	21.29	409.57	52	2330
3	5	4	-66.66972	-726.635	24.27	441.37	55	1705
3	5	5	-66.49027	-771.2698	36.95	461.89	80	36
1	1	1	-62.68299	-683.9637	23.88	459.28	52	99
1	1	2	-64.77831	-763.6175	22.81	438.7	52	94
1	1	3	-59.76975	-843.9369	39.99	336.07	119	84
1	1	4	-58.82568	-643.8356	40.28	327.5	123	2026
1	1	5	-62.9881	-819.3359	34.53	250.24	138	139
1	5	1	-65.83374	-797.8029	21.04	404.78	52	94
1	5	2	-62.36436	-706.2521	39.69	336.38	118	92
1	5	3	-61.94697	-805.4876	21.73	417.9	52	165
1	5	4	-62.67118	-742.6061	39.17	387.88	101	1848
1	5	5	-55.76263	-655.0355	40.08	313.13	128	1654
12	4	1	-51.42643	-412.0255	23.92	460.15	52	86
12	4	2	-51.81568	-508.9779	22.36	430.04	52	87
12	4	3	-55.84896	-611.5818	22.85	439.54	52	86
12	4	4	-51.08062	-446.4092	22.11	425.25	52	79
12	4	5	-58.04204	-503.7699	22.11	425.26	52	83
10	4	1	-48.67308	-522.8615	39.91	329.86	121	2133
10	4	2	-48.71237	-479.6438	39.49	313.43	126	81
10	4	3	-46.81072	-538.888	39.82	323.8	123	70
10	4	4	-47.80544	-527.7319	39.97	327.7	122	1851
10	4	5	-47.19095	-585.3948	39.97	302.8	132	90
12	8	1	-55.14412	-457.5138	21.15	406.82	52	51
12	8	2	-57.0406	-464.9582	39.53	376.52	105	49
12	8	3	-58.08777	-444.1552	24.28	466.98	52	52
12	8	4	-52.04652	-448.4868	20.44	393.25	52	52
12	8	5	-55.72331	-524.6606	35.11	531.97	66	55
10	8	1	-44.39625	-534.1329	39.5	352.68	112	1923
10	8	2	-45.41568	-562.8195	39.83	329.22	121	1840
10	8	3	-47.10931	-577.5757	39.61	332.88	119	1634
10	8	4	-50.70483	-555.9864	39.86	343.68	116	1868

10	8	5	-48.96972	-558.198	39.6	332.81	119	83
11	2	1	-53.66061	-500.5508	39.8	276.44	144	441
11	2	2	-51.7346	-494.4878	39.92	240.51	166	93
11	2	3	-51.20646	-463.2878	39.75	281.95	141	1589
11	2	4	-50.33997	-604.4903	39.88	260.66	153	130
11	2	5	-52.11356	-582.8619	39.71	287.8	138	1877
11	6	1	-56.60182	-550.8237	40.12	255.56	157	1918
11	6	2	-53.71395	-476.9325	40.04	242.68	165	1539
11	6	3	-39.20744	-479.5504	40.12	303.94	132	1835
11	6	4	-45.6828	-506.4945	39.93	277.3	144	850
11	6	5	-47.04266	-534.2292	40.18	277.1	145	1926
7	3	1	-54.31214	-497.5967	40.06	308.16	130	68
7	3	2	-42.16573	-555.6545	39.94	309.62	129	78
7	3	3	-55.25403	-663.0078	40.07	303.6	132	68
7	3	4	-37.60162	-414.6996	39.89	324.36	123	81
7	3	5	-56.12802	-557.4703	39.87	309.08	129	62
7	7	1	-52.47576	-555.7671	39.9	293.4	136	73
7	7	2	-53.04347	-606.4491	40.05	323.05	124	70
7	7	3	-49.42825	-619.5164	39.93	309.58	129	64
7	7	4	-51.8405	-657.486	40.11	308.59	130	70
7	7	5	-49.26967	-594.0056	40.11	323.53	124	71
13	3	1	-46.54079	-359.7088	40.31	195.68	206	84
13	3	2	-47.0475	-381.6705	39.34	325.17	121	77
13	3	3	-49.02396	-404.5668	16.67	320.72	52	73
13	3	4	-49.0144	-626.0858	24.88	478.61	52	74
13	3	5	-44.54404	-404.8719	19.99	384.56	52	85
14	1	1	-62.72454	-672.1554	39.37	310.02	127	2045
14	1	2	-63.54225	-659.4429	19.91	382.95	52	2021
14	1	3	-60.77378	-609.7412	21.01	404.17	52	116
14	1	4	-52.85419	-587.2593	25.69	494.03	52	117
14	1	5	-55.83476	-599.0143	39.68	283.46	140	106
13	7	1	-47.31482	-425.3554	39.73	345.48	115	95
13	7	2	-50.63882	-438.7116	32.95	477.63	69	78
13	7	3	-48.02161	-481.143	39.68	298.4	133	89
13	7	4	-44.6187	-337.1029	17.64	339.35	52	82
13	7	5	-47.88683	-409.6832	23.81	425.23	56	77
14	5	1	-66.56079	-689.5065	17.71	340.66	52	100
14	5	2	-67.55818	-711.0043	23.82	458.12	52	99
14	5	3	-65.48484	-698.3414	24.2	465.43	52	58
14	5	4	-67.53216	-667.5196	24.75	476.12	52	94
14	5	5	-67.53216	-667.5196	24.75	476.12	52	94
4	1	1	-61.00107	-894.6266	25.83	496.76	52	107
4	1	2	-63.26118	-785.7037	32.18	487.59	66	118
4	1	3	-63.48952	-873.4579	36.82	504.43	73	103
4	1	4	-62.96239	-843.7968	38.68	489.68	79	93
4	1	5	-60.7577	-1048.318	39.05	470.58	83	35

4	5	1 -61.03668	-840.0669	40.29	309.93	130	0
4	5	2 -64.16226	-1027.826	40.03	320.31	125	101
4	5	3 -56.62861	-901.5713	40.01	322.69	124	122
4	5	4 -61.45913	-981.1296	39.95	314.63	127	112
4	5	5 -59.71883	-1009.789	40.12	321.01	125	99
2	3	1 -48.31911	-400.549	19.27	370.58	52	107
2	3	2 -55.17767	-428.4177	39.13	420.81	93	101
2	3	3 -50.92961	-413.2528	22.71	436.84	52	127
2	3	4 -54.3899	-533.1907	39.63	341.66	116	105
2	3	5 -51.63851	-402.091	21.82	419.69	52	105
3	3	1 -53.11658	-649.8013	39.45	315.63	125	101
3	3	2 -48.81128	-568.0447	37.91	462.41	82	1836
3	3	3 -46.81751	-555.6293	40.49	323.96	125	51
3	3	4 -48.43635	-522.378	40.1	318.32	126	95
3	3	5 -49.37431	-542.3651	39.74	336.83	118	36
2	7	1 -63.23774	-505.9948	22.58	434.28	52	23
2	7	2 -61.87638	-527.5145	24.75	476.03	52	29
2	7	3 -55.56924	-531.3549	25.46	489.62	52	43
2	7	4 -53.49489	-578.4988	25.4	488.64	52	2546
2	7	5 -53.88709	-473.4564	29.7	571.16	52	107
3	7	1 -55.05834	-614.8682	20.19	388.42	52	114
3	7	2 -55.30275	-698.2412	24.13	464.05	52	86
3	7	3 -53.90259	-679.4644	23.06	443.62	52	85
3	7	4 -55.56659	-687.2549	21.66	416.7	52	84
3	7	5 -54.41892	-704.689	21.8	419.23	52	41
6	4	1 -44.25351	-512.1594	39.8	301.57	132	715
6	4	2 -46.49804	-567.3981	39.97	333.12	120	1841
6	4	3 -46.06076	-710.3894	39.41	331.24	119	1624
6	4	4 -46.77788	-567.1005	39.84	340.55	117	75
6	4	5 -45.07545	-599.6904	38.04	384.33	99	77
6	8	1 -45.30219	-548.8644	39.95	324.86	123	71
6	8	2 -49.32835	-518.6386	40.07	331.22	121	72
6	8	3 -46.90642	-623.3663	40.02	322.8	124	1778
6	8	4 -46.48742	-504.4327	39.79	315.79	126	1880
6	8	5 -50.75826	-494.1101	39.69	333.59	119	63
9	2	1 -51.02356	-583.6411	24.63	473.67	52	2071
9	2	2 -56.55257	-623.929	23.24	446.94	52	79
9	2	3 -50.50319	-619.7071	39.55	329.61	120	59
9	2	4 -45.06919	-473.2661	39.61	356.84	111	2065
9	2	5 -48.20004	-543.436	39.57	309.21	128	1896
15	4	5 -45.45718	-412.0579	39.77	375.21	106	47
15	4	1 -42.48336	-359.046	39.8	368.55	108	1805
15	4	2 -44.89915	-575.6569	40.03	339.3	118	1186
15	4	3 -43.18033	-471.3917	39.83	372.25	107	2023
15	4	4 -40.79355	-600.9951	39.82	379.3	105	1711
9	6	1 -58.20707	-629.9401	39.22	377.19	104	33

9	6	2	-57.30078	-683.814	39.21	369.95	106	28
9	6	3	-45.16158	-527.7863	39.51	343.64	115	79
9	6	4	-62.3049	-808.1465	39.38	393.87	100	31
9	6	5	-62.3049	-808.1465	39.38	393.87	100	31
9	6	5	-56.95648	-795.845	39.24	431.31	91	32
15	8	1	-43.69214	-453.1522	39.91	373.01	107	112
15	8	2	-38.92067	-405.8576	40.26	335.53	120	1690
15	8	3	-48.55513	-455.1201	40.02	360.55	111	113
15	8	4	-50.74463	-466.0201	39.68	389.04	102	26
15	8	5	-48.25107	-471.6759	40.15	316.16	127	32
8	4	1	-52.43813	-423.1167	40.1	297.07	135	87
8	4	2	-49.85094	-391.1128	40.03	281.9	142	85
8	4	3	-45.35311	-389.7476	40.19	287.08	140	78
8	4	4	-48.84123	-464.0942	39.33	351.16	112	78
8	4	5	-48.93354	-505.4126	40.39	282.45	143	50
8	8	1	-54.30662	-475.7585	36.1	410.24	88	66
8	8	2	-50.32707	-428.1068	19.29	371.05	52	71
8	8	3	-45.17738	-382.5874	39.66	305.12	130	78
8	8	4	-50.22955	-487.351	39.32	357.5	110	63
8	8	5	-38.06915	-357.8586	39.81	303.94	131	65
10	2	1	-58.82978	-564.1174	39.52	349.78	113	56
10	2	2	-61.18106	-734.9625	18.98	365.09	52	79
10	2	3	-59.12738	-579.5212	37.92	403.44	94	78
10	2	4	-62.48531	-603.4565	17.14	329.61	52	63
10	2	5	-52.31123	-579.6127	39.76	308.24	129	77
10	6	1	-57.71812	-610.4641	17.55	337.5	52	67
10	6	2	-54.99005	-702.034	30.87	474.95	65	723
10	6	3	-59.07126	-632.3643	32.06	439.23	73	1583
10	6	4	-57.54852	-664.1636	39.71	303.16	131	69
10	6	5	-54.13005	-574.1844	39.64	300.32	132	69
11	3	1	-42.43885	-369.8111	40.04	236.95	169	164
11	3	2	-46.38611	-454.4082	40.12	282.6	142	116
11	3	3	-45.87186	-569.6547	39.54	282.43	140	148
11	3	4	-46.97455	-389.4522	40.06	265.35	151	133
11	3	5	-41.5852	-311.5492	40.04	248.7	161	129
11	7	1	-46.56837	-422.9255	39.72	272.06	146	137
11	7	2	-48.83217	-490.3083	39.88	302.13	132	1667
11	7	3	-46.34212	-405.7088	40.06	267.07	150	121
11	7	4	-48.89907	-452.4002	39.62	285.09	139	120
11	7	5	-47.66042	-431.1627	39.82	281.59	142	511
7	2	1	-32.78465	-430.1114	40.02	363.87	110	31
7	2	2	-59.53737	-506.2046	40.21	321.74	125	34
7	2	3	-57.18991	-489.9864	39.81	349.28	114	29
7	2	4	-60.23508	-467.5026	39.82	313.59	127	30
7	2	5	-61.49519	-494.9989	39.74	308.1	129	33
7	6	1	-66.98589	-575.8686	39.59	344.34	115	80

7	6	2	-53.85814	-584.9233	40	327.89	122	67
7	6	3	-55.3117	-655.0422	39.97	338.81	118	65
7	6	4	-55.5179	-666.4963	40.06	317.97	126	60
7	6	5	-59.96449	-650.382	40.09	325.96	123	55
13	1	1	-53.41948	-537.705	40.18	264.35	152	81
13	1	2	-59.69788	-578.085	19.2	369.39	52	77
13	1	3	-59.06242	-756.4416	39.29	311.89	126	72
13	1	4	-61.69764	-693.9554	31.25	473.52	66	72
13	1	5	-62.45927	-675.8804	39.73	323.04	123	81
5	2	1	-57.94553	-505.1251	39.92	316.86	126	96
5	2	2	-51.52018	-412.7841	39.67	333.38	119	110
5	2	3	-48.32347	-567.8234	22.78	438.18	52	116
5	2	4	-52.99319	-588.7246	36.8	454.33	81	104
5	2	5	-48.86613	-431.9267	39.85	332.12	120	89
13	5	1	-57.02089	-659.4372	40.33	288.13	140	79
13	5	2	-58.1914	-733.4852	40.12	260.55	154	76
13	5	3	-57.36302	-564.5094	40.59	238.79	170	79
13	5	4	-57.93574	-667.2831	40.17	269.6	149	91
13	5	5	-50.19785	-715.0955	39.96	309.77	129	83
5	6	1	-52.92433	-610.8675	29.8	451.61	66	81
5	6	2	-50.16124	-597.7516	22.92	440.92	52	1943
5	6	3	-59.17279	-559.9508	25.65	493.31	52	2714
5	6	4	-63.20563	-723.4736	23.12	444.66	52	2629
5	6	5	-54.63073	-648.4614	39.37	401.83	98	106
4	4	1	-50.28531	-368.4511	39.75	281.94	141	25
4	4	2	-45.00955	-405.8475	40.13	258.94	155	24
4	4	3	-41.69855	-448.4262	39.99	275.83	145	25
4	4	4	-33.07736	-351.0828	40.05	276.23	145	25
4	4	5	-45.19626	-395.3619	39.97	253.03	158	27
4	8	1	-48.83551	-396.8906	35.09	433.27	81	134
4	8	2	-51.03046	-535.0857	38.04	427.42	89	108
4	8	3	-53.05784	-454.4182	34.97	522.02	67	113
4	8	4	-51.25061	-435.3885	40.15	282.77	142	129
4	8	5	-51.72149	-435.7281	39.9	273.35	146	32
1	2	1	-50.94789	-468.8377	39.6	335.6	118	41
1	2	2	-53.0434	-528.4519	39.89	316.66	126	86
1	2	3	-54.43584	-448.5073	39.35	367.78	107	1817
1	2	4	-54.57863	-499.876	25.98	447.96	58	45
1	2	5	-52.97847	-470.7174	39.41	325.74	121	35
1	6	1	-61.32246	-586.9565	21.21	407.96	52	96
1	6	2	-45.62606	-493.8841	39.64	381.15	104	1666
1	6	3	-46.30848	-510.5505	39.72	364.44	109	1884
1	6	4	-60.36931	-562.9454	24.23	466.14	52	2469
1	6	5	-57.45838	-524.6563	39	393.94	99	105
3	2	1	-59.1098	-554.5845	19.59	376.75	52	53
3	2	2	-57.57411	-448.0858	20.18	388.17	52	54

3	2	3	-61.07593	-594.0667	19.93	383.43	52	59
3	2	4	-49.78604	-601.6321	20.89	401.73	52	56
3	2	5	-57.26465	-478.9429	21.41	411.88	52	2762
6	2	1	-53.89297	-459.3849	39.2	340.88	115	103
6	2	2	-57.30552	-523.6473	23.27	394.52	59	77
6	2	3	-49.50023	-476.5029	22.32	429.39	52	69
6	2	4	-53.7122	-451.8013	19.96	383.89	52	79
6	2	5	-48.90878	-446.99	22.93	441.12	52	49
3	6	1	-58.26683	-565.4392	19.28	370.95	52	79
3	6	2	-55.75376	-517.1985	39.98	333.24	120	2151
3	6	3	-58.38094	-538.9247	39.07	336.88	116	69
3	6	4	-58.6179	-527.3867	39.53	362.74	109	1660
3	6	5	-44.93475	-403.7576	18.93	364.06	52	2644
6	6	1	-54.12745	-515.6851	18.3	352.06	52	86
6	6	2	-50.05027	-498.7964	20.55	395.25	52	101
6	6	3	-47.43565	-539.7549	19.91	382.92	52	89
6	6	4	-57.91508	-532.815	21.43	412.14	52	84
6	6	5	-51.77195	-558.7492	21.7	417.31	52	84
15	3	1	-48.04829	-504.3621	18.18	349.68	52	60
15	3	2	-45.26518	-417.6264	40.12	345.86	116	55
15	3	3	-38.34509	-477.0069	22.03	423.69	52	66
15	3	4	-38.59669	-424.3197	39.53	387.55	102	59
15	3	5	-35.86445	-376.955	38.32	485.07	79	54
15	7	1	-39.37645	-453.2823	39.87	372.66	107	150
15	7	2	-44.19149	-654.7814	39.43	394.3	100	21
15	7	3	-41.7747	-491.755	21.09	405.6	52	27
15	7	4	-38.74483	-426.867	23.85	458.77	52	21
15	7	5	-36.76322	-343.5216	21.23	408.42	52	21
9	4	1	-43.2154	-439.7068	39.6	322	123	103
9	4	2	-47.41024	-393.5151	34.34	451.94	76	82
9	4	3	-45.09214	-372.1876	39.26	350.62	112	106
9	4	5	-45.00088	-371.5181	39.78	303.74	131	92
9	4	4	-42.43272	-396.1048	39.79	323.53	123	87
9	8	1	-45.23115	-580.2278	39.87	356.06	112	74
9	8	2	-42.01565	-445.7841	39.69	339.28	117	75
9	8	3	-49.06982	-592.9985	40.05	354.48	113	76
9	8	4	-52.59904	-649.2996	38.49	442.49	87	79
9	8	5	-45.61441	-576.5667	39.86	340.76	117	77
14	3	1	-49.59209	-634.6874	39.81	306.27	130	56
14	3	2	-50.40993	-603.9924	40.04	298.83	134	79
14	3	3	-50.19809	-602.2625	39.26	347.45	113	80
14	3	4	-51.51381	-649.5895	39.3	316.97	124	77
14	3	5	-49.2928	-606.7448	40.04	290.15	138	97
14	7	1	-52.78413	-512.6509	39.45	352.29	112	97
14	7	2	-49.81468	-432.7059	39.64	314.6	126	74
14	7	3	-57.08337	-545.3071	39.4	358.2	110	59

14	7	4	-55.6931	-549.2115	40.03	320.26	125	100
14	7	5	-55.05961	-623.4713	39.67	330.66	120	77
12	3	1	-52.41622	-474.4625	39.88	346.85	115	95
12	3	2	-52.84044	-346.6168	39.73	317.91	125	86
12	3	3	-53.27464	-528.1353	39.49	315.93	125	75
12	3	4	-54.66383	-522.5544	39.25	373.86	105	76
12	3	5	-53.86116	-396.8649	39.5	334.74	118	89
12	7	1	-56.33664	-501.1387	40.02	312.68	128	38
12	7	2	-50.21035	-483.541	35.17	462.84	76	74
12	7	3	-53.73279	-425.6349	25.78	495.93	52	35
12	7	4	-55.42495	-443.8763	22.92	440.93	52	39
12	7	5	-54.36879	-475.1968	23.45	450.98	52	39
5	4	1	-43.62461	-410.6593	38.44	373.28	103	86
5	4	2	-38.76565	-396.8802	39.44	355.34	111	91
5	4	3	-35.99434	-426.8241	21.99	422.9	52	77
5	4	4	-36.7749	-427.5556	38.99	386.04	101	90
5	4	5	-37.41981	-421.7129	20.91	402.21	52	83
5	8	1	-45.48801	-635.7193	26.68	513.15	52	90
5	8	2	-47.7226	-494.2679	22.97	441.82	52	75
5	8	3	-47.60015	-496.9272	39.67	360.67	110	89
5	8	4	-48.34994	-428.0076	26.96	421.28	64	72
5	8	5	-43.44698	-497.2959	22.14	425.78	52	35
10	3	1	-53.56807	-428.8502	17	327.07	52	91
10	3	2	-50.75956	-515.0872	17.77	341.84	52	91
10	3	3	-50.84895	-427.2919	20.28	390.16	52	96
10	3	4	-49.31964	-490.7703	18.59	357.56	52	86
10	3	5	-49.80808	-531.9348	18	346.25	52	90
10	7	1	-54.14268	-558.9733	19.37	372.6	52	84
10	7	2	-49.37889	-630.9738	20.33	390.97	52	88
10	7	3	-52.72186	-603.1304	17.83	343.04	52	84
10	7	4	-52.48624	-614.8777	19.05	366.53	52	85
10	7	5	-52.40866	-663.2309	38.7	394.96	98	84
11	1	1	-60.53408	-799.3412	39.82	295	135	120
11	1	2	-59.12448	-836.0987	39.82	282.41	141	86
11	1	3	-55.18382	-814.6067	25.56	491.69	52	83
11	1	4	-55.01321	-815.5107	25.14	483.48	52	85
11	1	5	-57.46389	-816.3891	32.59	487.57	52	84
11	5	1	-57.17382	-556.0398	39.89	269.57	148	103
11	5	2	-61.1169	-825.1848	40.12	295.01	136	151
11	5	3	-59.38514	-728.6234	39.89	265.96	150	164
11	5	4	-59.73944	-720.6802	39.63	285.17	139	151
11	5	5	-58.39827	-700.8114	39.99	277.73	144	162
7	1	1	-66.18033	-852.2615	37.74	438.91	86	37
7	1	2	-66.15337	-785.4261	23.86	458.96	52	33
7	1	3	-64.7477	-918.9739	26.31	446.02	59	38
7	1	4	-63.41115	-831.8844	40.17	355.49	113	38

7	1	5	-58.98001	-905.0035	39.63	307.23	129	35
7	5	1	-68.52485	-800.7679	19.27	370.67	52	94
7	5	2	-58.53304	-847.269	40.2	295.65	136	95
7	5	3	-65.91199	-907.0339	39.55	366.26	108	83
7	5	4	-66.11662	-921.1016	32.18	487.67	66	80
7	5	5	-58.5975	-859.9081	40.22	311.79	129	86
13	4	1	-41.85404	-439.085	23.56	453.18	52	82
13	4	2	-39.609	-671.6523	28.48	547.77	52	77
13	4	3	-39.27095	-416.8646	24.22	465.84	52	78
13	4	4	-47.1073	-359.1175	23.05	443.28	52	81
13	4	5	-34.03284	-307.972	24.09	463.37	52	85
13	8	1	-41.73424	-390.6827	20.98	403.53	52	73
13	8	2	-44.13433	-433.671	24.05	462.62	52	87
13	8	3	-46.34628	-391.5906	24.69	474.95	52	83
13	8	4	-45.03229	-475.4343	23.63	454.58	52	86
13	8	5	-40.51747	-371.5181	25.2	484.61	52	72
2	4	1	-53.66593	-437.5594	22.33	429.57	52	111
2	4	2	-53.30695	-621.9911	27.92	526.84	53	1812
2	4	3	-56.0057	-510.9444	20.27	389.96	52	104
2	4	4	-51.51679	-463.7527	40.09	315.73	127	114
2	4	5	-55.71609	-496.0213	22.85	439.54	52	102
2	8	1	-57.13248	-530.8342	19.47	374.44	52	67
2	8	2	-49.29834	-411.7355	21.81	419.54	52	76
2	8	3	-49.77371	-485.8179	24.78	476.65	52	80
2	8	4	-54.49215	-571.9175	23.62	454.36	52	67
2	8	5	-54.96001	-564.3348	21.58	415.02	52	76
9	1	1	-72.24882	-822.4067	39.86	349.66	114	94
9	1	2	-61.24247	-896.2116	22.89	440.28	52	94
9	1	3	-63.03521	-848.2342	22.11	425.25	52	100
9	1	4	-65.95287	-864.0842	24.53	471.74	52	93
9	1	5	-65.21912	-749.4802	21.13	406.39	52	113
9	5	1	-58.52326	-766.0007	40.2	302.28	133	100
9	5	2	-74.99975	-963.8138	31.36	475.24	66	83
9	5	3	-70.11323	-1102.329	25.29	486.38	52	87
9	5	4	-70.08065	-1147.984	27.03	519.84	52	39
9	5	5	-69.21846	-1117.342	35.08	508.48	69	41
14	2	1	-42.19967	-371.5148	36.29	366.64	99	80
14	2	2	-44.69333	-367.5976	19.91	382.95	52	96
14	2	3	-50.4333	-540.6818	20.48	393.94	52	87
14	2	4	-42.71713	-386.0903	23.7	455.89	52	59
14	2	5	-38.61295	-309.0445	23.57	453.33	52	109
14	6	1	-52.18763	-478.8871	18.8	361.67	52	48
14	6	2	-46.91764	-437.7766	23.07	443.67	52	115
14	6	3	-49.25718	-393.5781	20.99	403.73	52	55
14	6	4	-39.54771	-481.4663	23.42	450.49	52	110
14	6	5	-48.10724	-446.1813	24.01	461.8	52	120

8	3	1 -53.84865	-489.3818	17.19	330.65	52	78
8	3	2 -53.23528	-484.0908	20.57	395.71	52	43
8	3	3 -44.45768	-402.3399	18.38	353.51	52	72
8	3	4 -53.75336	-462.9555	21.03	404.48	52	43
8	3	5 -49.65095	-460.1378	32.29	448.52	72	68
15	1	1 -60.23986	-806.406	21.52	413.89	52	75
15	1	2 -53.16472	-790.7476	26.58	511.29	52	97
15	1	3 -61.14904	-705.4711	24.68	474.68	52	46
15	1	4 -61.43165	-793.4857	24.79	476.83	52	278
15	1	5 -56.10789	-683.2047	23.28	447.82	52	110
8	7	1 -54.72712	-555.2458	19.18	368.87	52	48
8	7	2 -57.14244	-588.6369	18.77	361.09	52	48
8	7	3 -56.25651	-509.4247	18.52	356.29	52	46
8	7	4 -50.5937	-441.4849	19.49	354.42	55	47
8	7	5 -55.23246	-483.9501	24.14	377.22	64	46
15	5	1 -60.98142	-759.1858	22.78	438.15	52	70
15	5	2 -56.87433	-745.285	20.31	390.74	52	97
15	5	3 -58.36283	-673.3208	21.85	420.19	52	95
15	5	4 -54.82413	-721.755	22.72	436.97	52	97
15	5	5 -58.64379	-592.6246	22.12	425.56	52	96
16	2	1 -61.91903	-518.7528	40.27	254.88	158	110
16	2	2 -62.56502	-515.4991	37.81	444.88	85	103
16	2	3 -60.31352	-528.3795	40.03	283.93	141	92
16	2	4 -63.17834	-636.8484	26.24	504.67	52	90
16	2	5 -64.64295	-485.1169	22.61	434.95	52	102
16	6	1 -64.27895	-815.8093	37.61	458.72	82	50
16	6	2 -66.14024	-662.9715	37.96	441.39	86	55
16	6	3 -64.06628	-593.0109	39.95	307.36	130	60
16	6	4 -62.30247	-736.0582	39.18	340.74	115	58
16	6	5 -62.39404	-750.3443	33.02	478.68	69	51
16	4	1 -60.79853	-463.4571	39.94	285.31	140	80
16	4	2 -52.71288	-514.7676	39.38	283.31	139	76
16	4	3 -55.72976	-443.0466	24.45	470.21	52	70
16	4	4 -54.39024	-410.347	23.38	449.67	52	79
16	4	5 -57.69697	-489.5191	39.93	300.23	133	77
16	8	1 -61.05595	-712.0032	24.32	467.69	52	84
16	8	2 -60.98363	-662.342	25.87	497.63	52	83
16	8	3 -59.04588	-617.0983	24.95	479.94	52	78
16	8	4 -57.86215	-506.0367	40.2	287.2	140	78
16	8	5 -59.36604	-502.203	25.35	487.68	52	70
15	2	1 -52.20101	-430.2292	18.65	358.66	52	50
15	2	2 -49.85409	-401.6781	20.72	398.6	52	106
15	2	3 -46.23252	-468.667	18.53	356.39	52	111
15	2	4 -53.15679	-607.9312	19.75	379.95	52	77
15	2	5 -47.45848	-543.5715	22.09	424.82	52	2517
15	6	1 -57.05483	-534.7247	19.98	384.41	52	114

15	6	2	-52.67269	-550.0312	22.85	439.49	52	3893
15	6	3	-57.3753	-513.0405	22.61	434.91	52	2809
15	6	4	-51.93871	-408.2184	21.44	412.47	52	84
15	6	5	-44.00942	-478.0493	20.84	400.92	52	85
13	2	1	-31.33009	-380.8832	19.69	378.66	52	94
13	2	2	-33.80416	-409.9979	22.74	437.36	52	84
13	2	3	-53.53339	-444.622	19.2	369.23	52	75
13	2	4	-42.95186	-440.6767	19.63	377.52	52	88
13	2	5	-43.76458	-368.442	20.43	392.97	52	83
13	6	1	-47.0447	-425.3282	23.53	452.59	52	22
13	6	2	-51.78178	-534.7977	23.78	457.37	52	16
13	6	3	-57.80677	-550.5037	22.94	441.2	52	23
13	6	4	-60.58468	-539.0901	20.71	398.43	52	29
13	6	5	-56.47397	-503.3846	22.21	427.21	52	23
14	4	1	-46.73921	-452.0836	15.59	299.89	52	123
14	4	2	-45.07281	-541.9178	39.73	315.32	126	21
14	4	3	-47.47133	-535.4986	19.42	373.62	52	19
14	4	4	-42.59164	-469.5692	20.07	386.08	52	21
14	4	5	-39.40427	-469.6884	39.63	353.91	112	127
14	8	1	-48.32648	-485.0927	19.48	374.75	52	44
14	8	2	-50.70854	-469.2745	20.99	403.82	52	47
14	8	3	-34.56781	-411.2921	20.9	401.99	52	48
14	8	4	-44.3089	-410.2182	24.08	463.12	52	137
14	8	5	-50.62331	-634.6073	20.93	402.64	52	84
12	1	1	-68.17142	-902.2436	23.23	446.9	52	104
12	1	2	-62.67937	-812.3436	25.11	482.98	52	93
12	1	3	-63.17451	-806.9038	23.5	452	52	102
12	1	4	-65.32121	-851.2202	25.73	494.89	52	101
12	1	5	-67.15303	-817.6146	22.93	441.07	52	97
12	5	1	-63.66817	-743.9127	20.97	403.43	52	104
12	5	2	-63.74426	-664.1331	25.22	485.04	52	99
12	5	3	-66.06527	-748.0135	23.03	442.97	52	85
12	5	4	-65.49858	-817.9407	26.53	510.3	52	60
12	5	5	-64.40765	-738.6665	25.73	494.85	52	98
16	1	1	-67.6796	-793.9014	40.25	295.95	136	37
16	1	2	-66.67441	-743.1879	20.78	399.63	52	33
16	1	3	-67.87879	-663.7955	18.75	360.67	52	37
16	1	4	-69.68868	-644.5732	32.3	448.71	72	35
16	1	5	-70.50342	-731.7181	26.55	442.54	60	33
16	5	1	-67.64896	-726.3918	40.29	274.1	147	110
16	5	2	-72.46314	-936.9536	40.2	304.56	132	90
16	5	3	-74.88921	-953.1698	37.66	464.94	81	101
16	5	4	-69.28761	-941.1154	40.23	279.41	144	89
16	5	5	-64.35663	-847.7097	40.21	304.69	132	84
16	3	1	-48.97462	-421.8841	40.05	250.32	160	83
16	3	2	-48.92195	-394.2161	39.92	283.17	141	84

16	3	3	-49.1659	-379.8294	38.45	305.21	126	74
16	3	4	-49.1659	-379.8294	38.45	305.21	126	74
16	3	5	-49.29034	-502.2125	40.09	280.39	143	80
16	7	1	-55.48285	-708.5743	39.88	321.66	124	81
16	7	2	-50.99932	-562.4571	39.11	310.41	126	76
16	7	3	-46.90619	-534.9545	40.26	302.78	133	66
16	7	4	-47.99765	-463.5591	40.55	285.62	142	81
16	7	5	-54.19745	-524.8427	40.12	176.75	227	76

Table C2. Means and Standard Deviations

Condition	Total Inversion (°) M±SD	Max. Inv. Velocity (°/s) M±SD
Control		
Pre-Exercise	61.88 ± 5.14	749.04 ± 123.84
Post-Exercise	62.75 ± 5.73	767.53 ± 142.16
Tape Cast		
Pre- Exercise	52.68 ± 7.16	499.67 ± 77.77
Post-Exercise	55.74 ± 6.06	578.52 ± 97.19
Air-Stirrup		
Pre-Exercise	49.24 ± 4.29	478.23 ± 82.61
Post-Exercise	52.17 ± 4.89	545.15 ± 91.07
Tape/Brace		
Pre-Exercise	48.00 ± 7.69	486.83 ± 111.86
Post-Exercise	49.54 ± 5.87	492.96 ± 85.25