A COMPARISON OF ATHLETIC ANKLE TAPING TECHNIQUES WITH RESPECT TO ANKLE INVERSION

by

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ABSTRACT

The effects of restriction on ankle motion by athletic ankle taping was studied on twenty (n = 20) college football athletes. Pre-exercise and post-exercise ankle inversion motion was measured bilaterally under four conditions (a control - no taping, closed basketweave taping, moleskin stirrup taping, and spartan slipper taping). A modified Inman Ankle Testing Machine was used to obtain these measures. The design was a one factor randomized complete block design combined over days. Pre-exercise measures showed no significant ($p < .05$) difference between taping techniques but they were all statistically more restrictive than the control. There was also an interaction between the right and left foot. Post-exercise measures indicated a significant ($p < .05$) difference between taping techniques. The spartan slipper was the most restrictive of the taping techniques. The moleskin stirrup and the closed basketweave taping techniques were not statistically different from each other but they were significantly ($p < .05$) more restrictive than the control.

ACKNOWLEDGEMENTS

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CHAPTER 1

INTRODUCTION

Twenty-five percent of all injuries related to sports are ankle injuries (Garrick, 1975). Most of these injuries are sprains to the lateral ligaments as a result of excessive inversion forces (Garrick, 1977). Knight (1979) demonstrated that the rupture of lateral ankle ligaments occurs at the end of the inversion range of motion. Taping methods have been commonly used to reduce the range of motion of the ankle with the intent of not allowing the ankle to reach the point of inversion at which ligaments tear. Much research has been conducted on the ability of tape to limit ankle motion (Abdenour, Saville, White, and Abdenour, 1979; Delacerda, 1978; Fumich, Ellison, Guerin, and Grace, 1981; Glick, Gordon, and Nishimoto, 1976; Laughman, Carr, Chao, Youdas, and Sim, 1980; Malina, Plagenz, and Rarick, 1963; Morris and Musnicki, 1983; Rarick, Bigley, Karst, and Malina, 1962; Vaes, Boeck, Handelberg, and Opdecam, 1985). However, the research does not agree on the taping technique most efficient at controlling ankle inversion.

Purpose

Due to the frequency of ankle injuries in athletics, many athletic trainers are searching for additional and

more effective methods of managing these injuries. When an injury occurs, the athlete usually needs additional protection of the previously injured joint to resume athletic participation. The purpose of this study was to determine the effectiveness of the widely used closed basketweave taping technique and two variations of the closed basketweave (moleskin stirrup and spartan slipper) on controlling ankle motion. Inversion of the ankle joint was studied under a control (untaped) condition. Pre-exercise and post-exercise measurements were conducted for each treatment. The dependent variable was the inversion range of motion in degrees. The independent variables were the treatment form, the ankle used, and the exercise state.

Hypotheses

It was hypothesized that the treatment conditions (taping techniques) would be significantly different from each other with respect to their ability to restrict ankle inversion. The second hypothesis was that the treatment conditions would show equal loss of restriction of motion following an exercise bout. Third, it was hypothesized that a significant restriction of motion would remain following an exercise bout for each taping technique compared to the control.

Definition of Terms

Dorsiflexion. Dorsiflexion refers to movements of the foot and ankle in the sagittal plane in which the toes approach the lower leg (Donatelli, 1990).

Eversion. Eversion is a movement of the foot and ankle in the frontal plane laterally (Donatelli, 1990).

Eversion Neutral. Eversion Neutral refers to performing eversion with the longitudinal axis of the lower leg perpendicular to the longitudinal axis of the fifth metatarsal (Fumich et al., 1981).

Inversion. Inversion is a movement of the foot and ankle in the frontal plane medially (Donatelli, 1990).

Inversion Neutral. Inversion Neutral refers to performing inversion with the longitudinal axis of the lower leg perpendicular to the longitudinal axis of the fifth metatarsal (Fumich et al., 1981).

Isometric. Isometric is a contraction of a muscle statically without changing the muscle's length (Arnheim, 1989).

Plantar Flexion. Plantar Flexion refers to the movement of the foot and ankle in the sagittal plane in which the toes move away from the lower leg (Donatelli, 1990).

Sprain. A sprain is a traumatic joint twist that results in stretching or total tearing of the stabilizing connective tissues (Arnheim, 1989).

Supination. Supination refers to raising the medial margin of the foot (Arnheim, 1989).

Talar Tilt. Talar tilt refers to the angle (in the sagittal plane) of the talus in the mortise of the ankle (Donatelli, 1990).

Taping. Taping involves the use of linen or elastic tape to hold a body part in place (Arnheim, 1989).

Assumptions

Each subject was given the same instructions at each testing session. Therefore, it was assumed that the subjects relaxed their lower leg muscles in a consistent manner under each treatment condition so that their ankle motion was not affected by muscular contraction.

Also, it was assumed that the amount of torque applied to the ankle was consistent. The same amount of resistance (6 kg which resulted in an 11.76 N-m torque) was applied each testing session.

Delimitations

Actual rates for injury under each treatment condition were not studied. Only the amount of restriction of inversion at the ankle joint was studied.

Limitations

The amount of muscular guarding of the joint during

testing was not able to be controlled. The same instructions to relax the leg muscles were given each testing session. The tester waited thirty (30) seconds after adding the torque to the ankle before reading the inversion measurement.

CHAPTER 2

REVIEW OF LITERATURE

Overview

The limitation of ankle joint motion to prevent injury has been popular with athletic trainers for many years. Even so, some research has lead a few authors to believe that ankle taping is not beneficial to the athlete and may put them at greater risk for injury. Ferguson (1973) declared that tape loosens quickly during exercise and provides no significant support to the ankle. He supports his statement by adding that, because the tape slides over the skin and soft tissues of the leg, it does not protect the ligamentous structures of the ankle. Ferguson also claimed that the knee is predisposed to injury and the lower leg muscles are weakened when the ankles are taped. Further research has refuted Ferguson's work (Garrick and Requa, 1973; Laughman et al., 1980; Morris and Musnicki, 1983).

Motion Resistance Studies

The effects of tape on the ankle can be obtained by measuring the amount of resistance to motion. Rarick et al. (1962) and Malina et al. (1963) measured the amount of torque necessary to invert and plantar flex the ankle a fixed number of degrees. Rarick et al. found a forty

percent (40%) decrease in the initial resistance after ten minutes of exercise for all four of his taping techniques. He compared the closed basketweave taping, the closed basketweave with stirrups taping, the closed basketweave with heel lock taping and the closed basketweave with a combination of stirrups and heel lock taping technique. Malina et al. compared athletic ankle taping to cloth wraps. He compared the Louisiana Wrap and the closed basketweave with stirrups taping technique applied directly to the skin and over a stockinette. He also found that all of his taping and wrapping techniques lost their restrictive qualities over time. Neither author offered any data as to the statistical significance of their results.

Abdenour et al. (1979), studied the effects of torque on the range of motion of ankles that had been taped with a closed basketweave with heel lock taping technique. He found that taping had a significant reduction only on the inversion range of motion.

Greene and Hillman (1990) studied the restrictive qualities of one taping technique (a closed basketweave with figure of eights and heel locks) before, during, and after exercise. They found that after twenty minutes of exercise, the tape support had lost an average of forty-one percent of its combined inversion-eversion restrictive capabilities.

Fischer (1982) used a Cybex II Dynamometer (Cybex II Dynamometer: Cybex Division of Lumex Inc. Bay Shore, New York) with a special inversion-eversion adapter to compare the amount of torque and range of motion subjects were able to generate under three taping techniques (closed basketweave with two heel locks medially and two heel locks laterally, closed basketweave with two figure of eights, and closed basketweave with a combination of two heel locks medially and two heel locks laterally and two figure of eights). Only the pre-exercise inversion condition revealed results that allowed the author to conclude that torque production was not equal between taping techniques. The basketweave with two heel locks medially and two heel locks laterally limited torque production in this condition. There was a significant interaction between joint range of motion and torque production that followed the muscular length-tension relationship. The results of this study were in agreement with Abdenour et al. (1979), who also suggested that preventative ankle taping does not impair the maximum production of isometric torque.

Pope, Renstrom, Donnermeyer, and Morgenstern (1987) used a wooden model of a human ankle and subtalar joints to measure the restrictive qualities of athletic taping techniques on ankle inversion and eversion. The ankle joints were simulated by steel hinges screwed into the

wood. A cable was fitted through a hole drilled at the level of the first metatarsophalangeal joint. The model was taped using two techniques, a closed basketweave and a closed basketweave with figure of eights. The closed basketweave with the figure of eights was significantly more restrictive on the wooden ankle model. The use of this model may not be as valid as using an ankle of a human because there is no movement of the skin and these joints only moved in one plane.

Studies of Ankle Joint Motion

Another method of determining the effectiveness of tape is to quantitatively measure the motions of the ankle. This can be done by using various goniometric, cinematographic, and radiographic techniques.

Fumich et al. (1981) measured the restriction of ankle joint motion before and after a two and one-half to three hour football practice. The results showed that inversion neutral, plantar flexion-inversion, and eversion neutral retained 50% or more of their restriction after exercise compared to pre-exercise measurements. The taping technique used was a closed basketweave with two medial and two lateral heel locks.

A significant restriction of combined ankle inversion and eversion from athletic ankle taping was reported by Morris and Musnicki (1983). The taping

technique employed in their study was a Gibney basketweave with heel lock. Using a mechanical goniometer, the authors found a significant reduction in the supination motion of the ankle both before and after a two hour football practice.

A three-dimensional goniometer was used by Laughman et al. (1980) to study ankle joint motion. All conditions associated with inversion exhibited a significant reduction in motion when comparing the taped post-fifteen minute exercise bout condition to the untaped control condition. The taping technique used in this study was a closed basketweave with heel lock and a half figure of eight.

Radiographic studies of talar tilt were conducted by Glick et al. (1976) and Vaes et al. (1985). X-ray provides evidence of subtalar motion. The amount of talar tilt is an indication of the amount of inversion occurring at the ankle joint. Glick et al. found that the closed basketweave taping technique held the talus stable in the ankle mortise for up to twenty minutes of exercise, while Vaes et al. showed that the Gibney basketweave taping technique provided significant restriction of talar tilt before and after an exercise bout of thirty minutes.

From the above studies, tape appears to be effective at limiting the ankle from moving to the end of its range

of inversion motion. Therefore, tape is an effective means of preventing ankle sprains. However, none of the above studies compared the incidence of ankle sprains that occurred during taped to untaped conditions.

Studies of Ankle Injury Rates

In a study reviewing a survey done in 1967 with New York high school football players (n = 17,777), Ryan (1969) found that nearly twice as many ankle injuries occurred to players that were untaped as compared to taped or wrapped. Later, Garrick and Requa (1973) studied 2,562 intramural basketball players over a two year period. Their data showed that the injury rates of ankle sprains for untaped subjects (32.5 sprains/1,000 exposures) were over twice as high as that of taped subjects (14.6 sprains/1,000 exposures). Also, the untaped subjects suffered more severe (greater than first degree) ankle sprains when compared to the taped subjects.

Rovere, Clarke, Yates, and Burley (1987) presented the results of a study comparing the incidence of ankle sprains in football players wearing either tape or a reusable lace-up ankle brace. The taping technique used was a closed basketweave with a figure of eight and heel lock. This six year study of the Wake Forest University

football team involved two hundred ninety-six athletes and more than fifty thousand player exposures to injury. An exposure constitutes one practice or game. Injury rates varied by position but the injury rate for players using the brace was consistently lower than for taped players. Injury rates for the tape users varied from 2.70 to 5.88/1,000 exposures. Injury rates for those wearing the brace varied from 0.00 to 4.79/1,000 exposures.

Studies Comparing Taping Techniques

A review by Metcalf and Denegar (1983) concluded that athletic taping has significant value in supporting and protecting the ankle. They stated that taping is an effective adjunct to a sound conditioning or rehabilitation program in preventing ankle injury or reinjury.

Libera (1972) studied the effects of a football practice session on the support and retention of support of tape and wraps. He used ten football players at the wide receiver and defensive back positions as subjects. A Louisiana ankle wrap, Illinois ankle wrap, modified closed basketweave taping, modified closed basketweave taping with heel locks, and control (no tape or wrap) were randomly applied to the subjects. The practice session consisted of 110 minutes of the "usual drill and

scrimmage situations". The closed basketweave with heel locks taping technique maintained 72.5% of the initial support while the other experimental methods were approximately 65% effective. The taping methods gave significantly greater support (34%) than the wraps in pre- and post-exercise measurements. The author concluded that the closed basketweave with heel locks taping technique provided the best support to the ankle joint.

Seitz and Goldfuss (1984) compared a closed basketweave taping method with the Hinton-Boswell method of taping. They took control measures of the subjects' ankle motion, taped the subjects with both methods on separate days, took ankle motion measurements, put the subjects through an exercise session, and retested range of motion of the ankle. Their results showed that initially the Hinton-Boswell method of taping was the more restrictive. After the exercise session, both methods were equally restrictive. The authors concluded that either method of taping was adequate for restricting ankle motion.

Inman Ankle Testing Machine

Inman (1976) designed a testing device to measure the ankle range of motion for inversion and eversion under different conditions of plantar flexion and

dorsiflexion. The ankle joints were aligned with the axis of rotation of the machine. By observing the amount of rotation of the turntable, the number of degrees of ankle motion could be recorded. Any combination of plantar flexion, dorsiflexion, eversion, or inversion could be measured. Originally, the number of degrees of motion was measured by using a mechanical goniometer. The center of the goniometer was aligned with the center of the ankle joint and the two axes from the center of the goniometer were lined up parallel to the longitudinal axis of the fifth metatarsal and the fibula, respectively. Angles between these axes were used to determine starting positions and ranges of motion. Several modifications of Inman's device have been made by other researchers, including electronic equipment to digitally read the number of degrees of motion (see Appendix A).

CHAPTER III

METHODS

Subjects

Twenty (n = 20) males, ranging in age from 19 to 22 years, volunteered to participate in this study. The subjects' physical condition was excellent. Body weight varied among the subjects, ranging from 155 pounds to 220 pounds. All subjects were members of the Michigan State University football team, playing at a variety of positions. Each subject had no previous injury to their ankles that affected their range of motion as self-reported on the subject profile sheet (see Appendix B).

Design

The design was a one factor randomized complete block design combined over days. Four types of restriction (control, closed basketweave, closed basketweave with a moleskin stirrup, and closed basketweave with a spartan slipper) and two levels of the exercise condition (pre-exercise and post-exercise) were tested. All subjects were tested under all conditions. Random assignment of the order for the four types of restriction was made for each subject. The twenty subjects were divided randomly into four groups of five. Each group was then randomly assigned a predetermined

order of treatment variables. The four orders were: 1) control, closed basketweave, closed basketweave with a moleskin stirrup, and closed basketweave with a spartan slipper; 2) closed basketweave with a spartan slipper, closed basketweave with a moleskin stirrup, closed basketweave, and control; 3) closed basketweave, closed basketweave with a spartan slipper, control, and closed basketweave with a moleskin stirrup; and 4) closed basketweave with a moleskin stirrup, control, closed basketweave with a spartan slipper, and closed basketweave. Each subject number was assigned to a group before the number was given to the subjects so there would not be any biasing of the groups or the order of the treatment variables.

Treatment

Two types of treatment conditions (restriction and exercise) were studied for each subject. The restriction condition consisted of four types: 1) control, 2) closed basketweave, 3) closed basketweave with a moleskin stirrup, and 4) closed basketweave with a spartan slipper. In the control condition, the subjects wore nothing on their ankle. For the closed basketweave level, the subjects had their ankles taped with Johnson & Johnson (Johnson & Johnson Products, Inc. New Brunswick, NJ 08903) 2" Zonas athletic tape. Each subject was taped

by the same certified athletic trainer. Spray tape adherent, pre-wrap, and heel-and-lace pads were applied to the subject's ankles. A closed basketweave technique with two medial heel locks and two lateral heel locks was used for the tapings (see Appendix C). For the closed basketweave with moleskin taping technique, the subject was given a closed basketweave taping with two medial heel locks and two lateral heel locks with the addition of a moleskin stirrup added before the heel locks were applied (see Appendix D). For the closed basketweave with a spartan slipper taping technique, the subject was given a closed basketweave taping with two medial heel locks and two lateral heel locks with the addition of a piece of 3" Elastikon (Johnson & Johnson Products, Inc. New Brunswick, NJ 08903) that was approximately 18 inches long, in which the ends were split down the middle so that when it was applied as a stirrup (medial to lateral) the ends could be wrapped around the lower leg just above the malleoli (see Appendix E). The spartan slipper was also added before the heel locks.

The exercise condition consisted of two levels (pre-exercise and post-exercise). Pre-exercise measurements were taken immediately after application of the tape. Post-exercise measurements were taken immediately after the exercise bout was completed. The exercise consisted of agility drills (see Appendix F) Michigan State

University football players perform during conditioning practice. These lasted approximately one hour.

Procedures

All testing was carried out in the Michigan State University athletic training room located in the Duffy Daugherty Football Building. Each subject was tested eight times, once under each of the four restrictions, both before and after the exercise regimen. Only one session was done per day and all four sessions were conducted within one week.

Each subject had the inversion motion of his right and left ankle measured pre-exercise and post-exercise under all four types of restriction. The instrument used to perform the measurements was a modified Inman Ankle Testing Machine (see Appendix A). The Inman Device was set so that the only movement permitted was at the subtalar joint of the ankle, allowing only inversion and eversion. The calcaneus was stabilized with a vise-like clamping system. It was made out of wood and the contact areas were padded with grey memory foam. The clamp was positioned low enough on the calcaneus to stabilize the foot to the foot plate and still allow normal inversion and eversion. The toes of the foot were also stabilized with a velcro strap that did not interfere with the taping techniques. The subject was reclined on a testing

table with the knee flexed (so that the lower leg muscles would not be on stretch to interfere with ankle range of motion) and the ankle joint in a neutral position (90 degree angle of the fifth metatarsal relative to the longitudinal axis of the lower leg). The lower leg was stabilized with velcro straps to isolate movement to the ankle joint. The subjects were told to lie back and relax throughout the entire testing procedure (see Appendix G). No shoes or socks were worn during the measurements. For the exercise sessions, low-top, flat bottom shoes were worn and the subjects wore the same pair of shoes for each session.

The procedure for testing was explained to the subject at a meeting prior to the first testing session. The subject was instructed to relax the muscles of his lower leg as the torque causing the inversion was applied. The subject was taped (if appropriate) and secured into position on the testing table for measurement. After the subject was properly positioned, the tester moved the foot plate of the Modified Inman Ankle Testing Machine to a neutral position as indicated by a reading of 0 degrees on the digital readout. A six kilogram weight was then added to the end of the pulley system to produce an 11.76 N-m torque causing inversion of the ankle joint. To allow the subject to fully relax his lower leg, the tester waited 30 seconds from the time

the weight was applied until the reading of the inversion motion was taken. Measurements were taken and recorded on the subject's record sheet (see Appendix H).

Control

In order to obtain reliable results and isolate any effects seen to the treatment conditions, several factors had to be controlled in this study.

The exercise sessions were controlled so that all the exercises were approximately the same duration, distance, and intensity. It was also controlled by having four groups, each having a separate treatment for that session. Therefore, we can assume that similar stresses were placed on the ankle joint during the session for each type of restriction.

Each subject wore the same low-top shoes and similar socks each session so that the amount of traction and ankle support could be assumed to the consistent across all subjects.

The amount of torque causing inversion was always the same since the same weight was applied in the same manner before and after each exercise session. The weight used was 6.0 kg (Inman, 1976 and Wilson, 1990). This weight generated enough torque (11.76 N-m) to cause significant inversion-eversion without generating so much

torque as to cause muscular guarding of the ankle joint.

Reliability and objectivity of the modified Inman Ankle Testing Machine was tested by having the twenty subjects' right ankle tested twice by two separate testers prior to collecting experimental data. Reliability testing of each subject was conducted under control conditions. One test was immediately followed by the second to minimize the effects of any intervening factors on ankle range of motion. The subjects were strapped into the machine as previously described. The inversion measure in degrees was recorded. The subject was then completely removed from the machine and immediately retested by another tester who had no knowledge of the results of the first test. The measures for each subject were then correlated to determine the reliability of the measures. The results of this will be discussed in Chapter 4.

Statistical Analysis

The design was a one factor randomized complete block design combined over days. An analysis of variance was performed to test for main effects and an interaction effect. The Least Significant Difference test ($p<.05$) was used to separate means.

CHAPTER 4

RESULTS

Reliability of the Modified Inman Machine

As a reliability check of the modified Inman Ankle Testing Machine, the inversion range of motion in degrees of twenty subjects in the control condition (no tape) were measured twice by two separate testers. Each subject was completely unstrapped before the second measurements were started. The tester did not see the digital display for any of the measures to bias the results. The mean and standard deviation for all first trials were 30.8 (5.8) and for all second trials were 31.2 (4.7). A Pearson correlation coefficient of .919 indicated a positive relationship and very good reliability between trials. The results are summarized in Table 1.

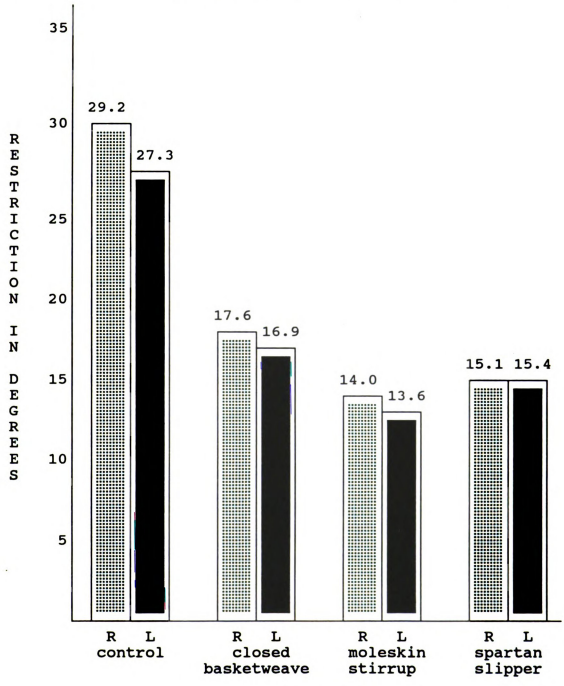
Main Effects

The means in degrees for pre-exercise inversion measures for the right/left foot were 29.2/27.3 for the control, 17.6/16.9 for the closed basketweave, 14.0/13.6 for the moleskin slipper, and 15.1/15.4 for the spartan slipper. Figure 1 shows the right and left foot measures for each treatment. The Least Significant Difference test (alpha 0.05) separated the pre-exercise means for

TABLE 1. CORRELATION DATA (IN DEGREES) FOR THE MODIFIED INMAN ANKLE DEVICE WITH SUBJECTS IN CONTROL CONDITIONS.

SUBJECT NUMBER	TRIAL ONE	TRIAL TWO
1	29	31
2	32	29
3	31	29
4	26	29
5	29	30
6	31	34
7	25	29
8	34	32
9	32	36
10	23	24
11	44	43
12	30	32
13	43	39
14	41	39
15	24	25
16	26	27
17	26	29
18	30	28
19	31	30
20	28	29
MEAN	30.8	31.2
STANDARD DEVIATION	5.8	4.7
PEARSON CORRELATION COEFFICIENT	0.919	

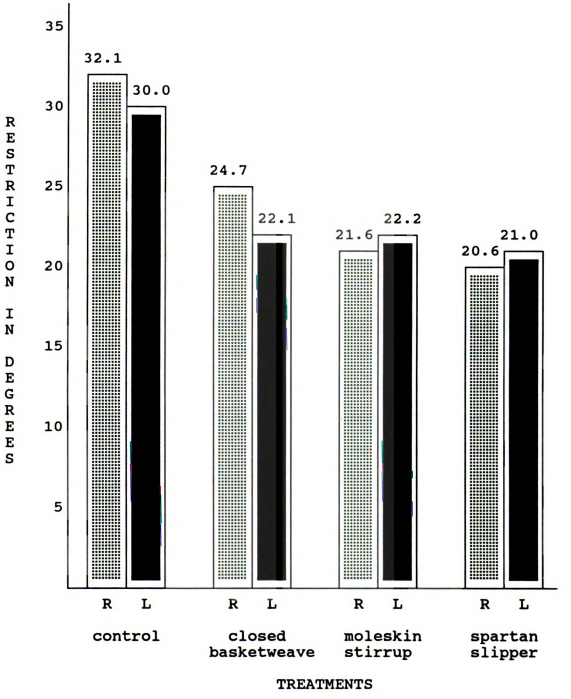
FIGURE 1. RIGHT AND LEFT FOOT PRE-EXERCISE INVERSION MEASURES FOR EACH TREATMENT AVERAGED OVER FOUR DAYS.



the right and left foot with values of 3.6 and 3.8, respectively. All ankle taping techniques significantly ($p < .05$) differed from the control group, but the ankle taping techniques did not significantly differ from each other. Figure 2 shows the right and left measures for each treatment. The post-exercise means in degrees for the right/left foot were 32.1/30.0 for the control, 24.7/22.1 for the closed basketweave, 21.6/22.2 for the moleskin stirrup, and 20.6/21.0 for the spartan slipper. For the right and left foot all of the ankle taping techniques significantly ($p < .05$) differed from the control group. The Least Significant Difference test separated the post-exercise means for the left and right foot with values of 4.1 and 4.2, respectively. The post-exercise measures for the ankle taping techniques on the left foot did not significantly ($p < .05$) differ from each other. The post-exercise measures on the right foot for the closed basketweave (24.7 degrees) were significantly ($p < .05$) different from the spartan slipper measures (20.6 degrees) but the moleskin stirrup measures (21.6 degrees) were not different than either of them.

The difference between post-exercise and pre-exercise inversion measures was analyzed for significant differences. These measures in degrees were 2.8 for the control, 6.2 for the closed basketweave, 8.1 for the

FIGURE 2. RIGHT AND LEFT FOOT POST-EXERCISE INVERSION MEASURES FOR EACH TREATMENT AVERAGED OVER FOUR DAYS.



moleskin stirrup, and 5.6 for the spartan slipper. The Least Significant Difference test (3.1) indicated that the control significantly ($p < .05$) differed from the closed basketweave and moleskin stirrup ankle taping techniques but the spartan slipper was not different from any of the treatments.

Table 2 contains the percentage of restriction lost and the number of degrees lost for each treatment comparing pre-exercise and post-exercise measures. The moleskin stirrup lost the most degrees (8.1) followed by the closed basketweave (6.2), spartan slipper (5.6), and the control (2.8).

There were no significant differences between the days or the absolute differences between feet for left minus right foot inversion measurements, either pre-exercise or post-exercise. All of the main effects are summarized in Table 3. The degrees of freedom and mean square for each condition are listed in Table 4.

Interaction Effect

The pre-exercise inversion measures for left minus right foot were significant with an alpha of .05. The means were separated with the Least Significant Difference test. Table 5 displays the Interaction effects.

TABLE 2. MEANS OF INVERSION IN DEGREES, PERCENT OF INVERSION LOST, AND AVERAGE NUMBER OF DEGREES LOST FOR EACH TREATMENT COMBINED ACROSS DAYS.

	PRE-EXERCISE	POST-EXERCISE	AVERAGE DEGREES	PERCENT LOST
CONTROL AVERAGE	28.2	31.0	2.8	9.0
CLOSED BASKET-WEAVE AVERAGE	17.2	23.4	6.2	26.5
MOLESKIN STIRRUP AVERAGE	13.8	21.9	8.1	37.0
SPARTAN SLIPPER AVERAGE	15.2	20.8	5.6	26.9

TABLE 3. EFFECTS OF ANKLE TAPING TECHNIQUES ON INVERSION MEASUREMENTS FOR LEFT AND RIGHT FEET AND PRE- AND POST-EXERCISE CONDITIONS.

TAPING TECHNIQUE	RIGHT FOOT PRE-EXER-CISE	LEFT FOOT PRE-EXER-CISE	RIGHT FOOT POST-EXER-CISE	LEFT FOOT POST-EXER-CISE	POST-MINUS PRE-EXER-CISE
CONTROL	29.2	27.3	32.1	30.0	2.8
CLOSED BASKET-WEAVE	17.6	16.9	24.7	22.1	6.2
MOLESKIN STIRRUP	14.0	13.6	21.6	22.2	8.1
SPARTAN SLIPPER	15.1	15.4	20.6	21.0	5.6
LSD	3.8	3.6	4.2	4.1	3.1

LSD - LEAST SIGNIFICANT DIFFERENCE

TABLE 4. DEGREES OF FREEDOM AND MEAN SQUARES FOR EACH OF THE CONDITIONS. ALL MEAN SQUARES WERE CALCULATED FROM MEASURES IN DEGREES. PRE- AND POST- REFER TO PRE-EXERCISE AND POST-EXERCISE MEASURES.

SOURCE	DEG OF FREE-DOM	MEAN SQUARE FOR RIGHT /LEFT FOOT PRE-	MEAN SQUARE FOR LEFT MINUS RIGHT FOOT PRE-	MEAN SQUARE FOR RIGHT /LEFT FOOT POST-	MEAN SQUARE FOR LEFT MINUS RIGHT FOOT POST-	MEAN SQUARE FOR POST-MINUS PRE-
DAYS	3	24.9 /9.7	29.2	32.6 /23.3	78.6	8.3
ERROR	16	24.5 /18.0	43.4	30.0 /26.2	52.4	5.8
TREAT-MENT	3	968.8 /53.3	16.2	541.1 /346.0	54.1	93.5
INTER-ACTION BET-WEEN DAYS AND TREAT-MENT	9	40.2 /61.8	69.3	42.0 /31.0	44.3	22.6
ERROR	48	34.8 /31.6	25.9	43.6 /40.8	25.6	24.5

TABLE 5. ABSOLUTE DIFFERENCES BETWEEN LEFT AND RIGHT FOOT INVERSION MEASUREMENTS IN THE PRE-EXERCISE CONDITION. EACH TREATMENT ANALYZED BY THE DAY.

TAPING TECHNIQUE	DAY ONE	DAY TWO	DAY THREE	DAY FOUR
CONTROL	3.0	4.0	-6.8	-7.8
CLOSED BASKETWEAVE	-1.6	-2.2	-0.6	1.6
MOLESKIN STIRRUP	2.0	-2.6	-0.6	-0.4
SPARTAN SLIPPER	-0.8	0.2	-0.6	2.2
LEAST SIGNIFICANT DIFFERENCE	3.2			

CHAPTER 5

DISCUSSION

Reliability of the Modified Inman Machine

As can be seen the high Pearson correlation coefficient (r = 0.919) yielded by the test-retest comparisons (Table 1), the modified Inman Ankle Testing Machine was reliable. The measurement of the subjects was consistent.

Restriction of Inversion

A significant main effect for the exercise factor showed that all groups (control, closed basketweave, moleskin stirrup, and spartan slipper) allowed more inversion following the exercise bout. The increase for the taping techniques was at least 25 percent and for the control group only nine percent (see Table 2). Lyle (1987) stated that the loss of restriction or increase in range of motion was due to a "warming up effect of the ankle joint and associated muscles" and not as much a loosening of the tape. This data is inconsistent with his statement.

Since there was not a significant difference between the ankle taping techniques in the pre-exercise condition, none of the ankle taping techniques can be judged more or less effective at limiting ankle inversion

initially. All taping techniques provided significant inversion restriction compared to the control group. Even though the ankle taping techniques were not different statistically, it is interesting to note that the moleskin stirrup is the most restrictive with an average of 13.8 degrees of inversion followed by the spartan slipper and closed basketweave taping techniques with averages of 15.3 and 17.2 degrees of inversion, respectively. These degrees of inversion for the pre-exercise condition are averaged over the left and right feet. The moleskin stirrup had a tendency to be more restrictive, initially.

Post-exercise measures indicate there was a statistical difference between ankle taping techniques (Table 3). All of the ankle taping techniques were significant ($p < .05$) at restricting ankle inversion as compared to the control. The spartan slipper taping technique on the right foot was significantly more restrictive than the closed basketweave but the moleskin stirrup was not statistically different from either of them. The spartan slipper (20.6 degrees of inversion) was the most effective at limiting ankle inversion post-exercise on the right foot. The moleskin stirrup (21.9 degrees of ankle inversion) was a few degrees more restrictive than the closed basketweave (23.4 degrees of inversion).

The significant differences between ankle taping techniques between post-exercise and pre-exercise conditions was tested (Table 3). To find the average number of degrees lost (Table 2), the pre-exercise averages in degrees were subtracted from the post-exercise averages for each treatment, respectively. The control lost statistically less restriction of inversion than the closed basketweave or moleskin stirrup ankle taping techniques. However, the spartan slipper was not significantly different from any of the other treatments.

The moleskin stirrup lost the most number of degrees due to the placement of the moleskin onto the anchors of the base tape on the lower leg. Therefore, all of the forces from normal ankle motions are placed on the foundation of the taping technique, which puts more stress on the anchors causing slippage, and allows increased inversion range of motion. Conversely, the spartan slipper retains more of its restrictive capacities because it does not attach to the anchors of the lower leg but instead circumvents the stirrups of the base tape and, by pulling them closer to the contours of the ankle, makes the taping technique more restrictive to inversion range of motion.

There was only one significant interaction (Table 5). It occurs between the treatment and the days during pre-exercise measures. Initially, there was a difference

between the left and right foot for the amount of restriction of inversion between the treatments and the days. On days two, three, and four the control measures for the left and right foot were significantly different from all of the taping techniques. On day one the control measures were significantly different from the closed basketweave and spartan slipper taping techniques. The moleskin stirrup taping technique was only statistically different from the closed basketweave. This could indicate that either foot has a tendency to be more restrictive than the other. Because of the lack of an interaction for post-exercise measures between the taping techniques and the days, all of the treatments lost inversion restriction at similar rates on the left and right feet.

Conclusions

All of the ankle taping techniques were significantly ($p < .05$) more restrictive in inversion range of motion than the control group. Due to the lowest degrees of inversion for the spartan slipper on the right foot during post-exercise measures, its ability to maintain the inversion restriction post-exercise, and relatively greater restriction of inversion pre-exercise, the spartan slipper was the best taping technique to limit inversion motion of the ankle. The moleskin

stirrup, although not statistically significant, was more restrictive than the closed basketweave in pre-exercise and post-exercise measures.

The closed basketweave taping technique used in this investigation was significant ($p < .05$) compared to the control group at restricting inversion motion and should be utilized as part of the athletic trainer's arsenal to prevent inversion ankle sprains, protect against re-injury, and reduce the severity of injury from inversion torque in athletics. However, if an athlete sprains his/her ankle and needs additional support and protection from inversion forces, a better choice is the spartan slipper or moleskin stirrup.

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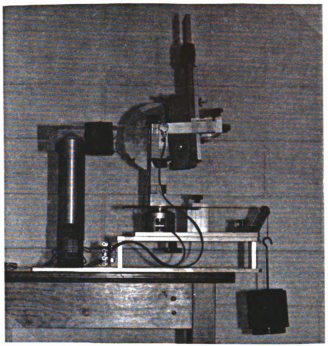
BIOGRAPHICAL SKETCH

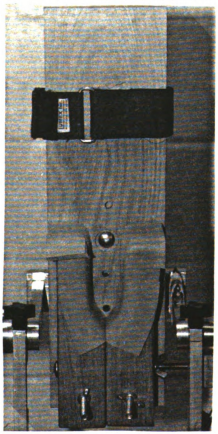
Paul Edward Plummer was born March 3, 1967 in Defiance, Ohio. He graduated from Central Noble High School in Albion, Indiana in 1985. He then earned his Bachelor of Science degree from Southern Illinois University in Carbondale, Illinois in 1989. He majored in Physical Education with an emphasis in Athletic Training. He then studied Human Performance with an emphasis in Athletic Training at Michigan State University in East Lansing, Michigan, to earn a Master of Arts degree in 1991. He is a member of the National Athletic Trainer Association and Great Lakes Athletic Trainers Association.

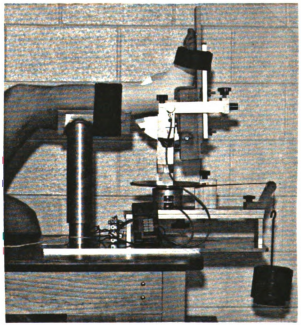
APPENDIX A

MODIFIED INMAN ANKLE TESTING MACHINE



A - MACHINE AS IT LOOKS TODAY WITH ELECTRONICS AND CALCANEOUS STABILIZING EQUIPMENT ADDED.





B - NOTE STRAPS DO NOT INTERFER WITH TAPING AND STILL STABILIZES THE FOOT.

C - WOODEN VISE-LIKE CLAMPING SYSTEM TO STABILIZE THE CALCANEOUS TO ALLOW NORMAL ANKLE INVERSION MOTION.

APPENDIX B

SUBJECT PROFILE SHEET

SUBJECT PROFILE SHEET

NAME_____ STUDENT NUMBER_____

1. HAVE YOU EVER HAD ANY ANKLE INJURY? YES NO

2. IF YOU HAVE HAD AN ANKLE INJURY, DID YOU SEE A PHYSICIAN? YES NO

3. DID YOU HAVE TO BE PUT ON CRUTCHES BECAUSE OF THE INJURY? YES NO

4. HOW LONG WERE YOU UNABLE TO PARTICIPATE IN YOUR SPORTING ACTIVITIES? 1-3 DAYS 3-8 DAYS 8-24 DAYS 24+ DAYS

5. DOES YOUR ANKLE FEEL UNSTABLE IN ANY ACTIVITY? YES NO

6. HAVE YOU EVER BEEN TOLD BY ANY MEDICAL PERSONNEL THAT YOU HAVE UNSTABLE ANKLES? YES NO

7. WHAT IS YOUR PRESENT BODY WEIGHT? _____POUNDS

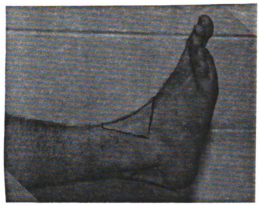
8. WHAT POSITION DO YOU PLAY? _____

9. HEIGHT _____ AGE _____

10. WHAT IS YOUR PHYSICAL ACTIVITY LEVEL?
LOW MODERATE HIGH

APPENDIX C

CLOSED BASKETWEAVE TAPING TECHNIQUE



A- HEEL AND LACE PADS APPLIED TO ANKLE SPRAYED WITH TAPE ADHERENT.

B - THIN LAYER OF PRE-WRAP APPLIED TO COVER ANKLE AND PADS.

C- THREE ANCHORS APPLIED TO LOWER LEG AND ONE ANCHOR PROXIMAL TO THE BASE OF THE FIFTH METATARSAL ON THE FOOT.

D - FIRST STIRRUP AND HORSESHOE APPLIED MEDIAL TO LATERAL.

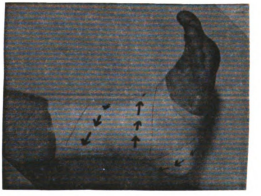
E- SECOND STIRRUP AND HORSE-SHOE APPLIED MEDIAL TO LATERAL.

F - THIRD STIRRUP AND HORSESHOE APPLIED MEDIAL TO LATERAL.

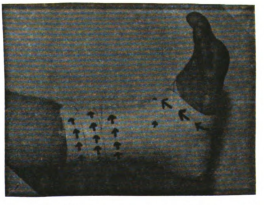
G- FIRST MEDIAL HEEL LOCK APPLIED.

H- FIRST LATERAL HEEL LOCK APPLIED.

I- SECOND MEDIAL HEEL LOCK APPLIED.



J- SECOND LATERAL HEEL-LOCK APPLIED.

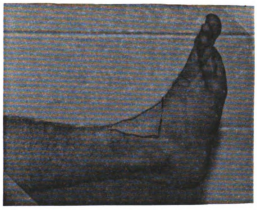


K- ANCHORS USED TO "CLOSE" TAPING, THREE ANCHORS ON THE LOWER LEG AND ONE ANCHOR PROXIMAL TO THE BASE OF THE FIFTH METATARSAL ON THE FOOT.

L- FINISHED CLOSED BASKET-WEAVE TAPING.

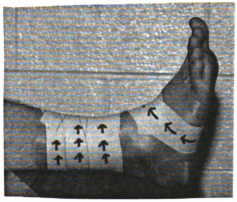
APPENDIX D

MOLESKIN STIRRUP TAPING TECHNIQUE

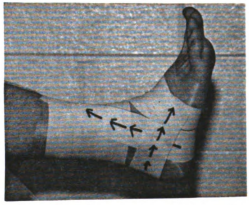


A- HEEL AND LACE PADS APPLIED TO ANKLE SPRAYED WITH TAPE ADHERENT.

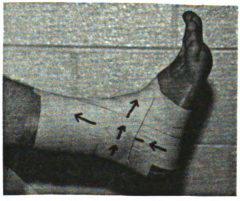
B- THIN LAYER OF PRE-WRAP APPLIED TO COVER THE ANKLE AND PADS.



C- THREE ANCHORS APPLIED TO LOWER LEG AND ONE ANCHOR PROXIMAL TO THE BASE OF THE FIFTH METATARSAL ON THE FOOT.



D- FIRST STIRRUP AND HORSESHOE APPLIED MEDIAL TO LATERAL.



E- SECOND STIRRUP AND HORSE-SHOE APPLIED MEDIAL TO LATERAL.

F- THIRD STIRRUP AND HORSESHOE APPLIED MEDIAL TO LATERAL.

G- MOLESKIN STIRRUP ADDED MEDIAL TO LATERAL.

H- FIRST MEDIAL HEEL LOCK APPLIED.

I- FIRST LATERAL HEEL LOCK APPLIED.

J- SECOND MEDIAL HEEL LOCK APPLIED.

K- SECOND LATERAL HEEL LOCK APPLIED.

L- ANCHORS USED TO "CLOSE" TAPING, THREE ANCHORS ON THE LOWER LEG AND ONE ANCHOR PROXIMAL TO THE BASE OF THE FIFTH METATARSAL OF THE FOOT.

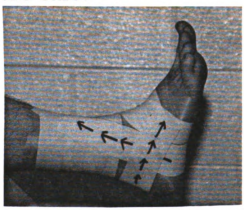
APPENDIX E

SPARTAN SLIPPER TAPING TECHNIQUE

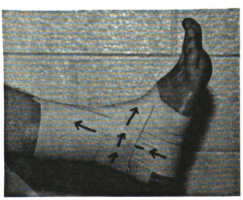
A- HEEL AND LACE PADS APPLIED TO ANKLE SPRAYED WITH TAPE ADHERENT.

B- THIN LAYER OF PRE-WRAP APPLIED TO COVER THE ANKLE AND PADS.

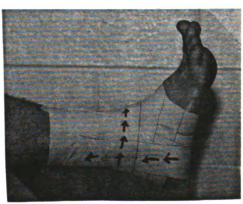
C- THREE ANCHORS APPLIED TO LOWER LEG AND ONE ANCHOR PROXIMAL TO THE BASE OF THE FIFTH METATARSAL ON THE FOOT.



D- FIRST STIRRUP AND HORSESHOE APPLIED MEDIAL TO LATERAL.



E- SECOND STIRRUP AND HORSE-SHOE APPLIED MEDIAL TO LATERAL.



F - THIRD STIRRUP AND HORSESHOE APPLIED MEDIAL TO LATERAL.

G- ELASTIKON ENDS SPLIT DOWN THE MIDDLE AND WRAPPED AROUND LOWER LEG PROXIMAL TO BOTH MALLEOLI, MEDIAL TO LATERAL.

H- FIRST MEDIAL HEEL LOCK APPLIED.

I- FIRST LATERAL HEEL LOCK APPLIED.

J- SECOND MEDIAL HEEL LOCK APPLIED.

K- SECOND LATERAL HEEL LOCK APPLIED.

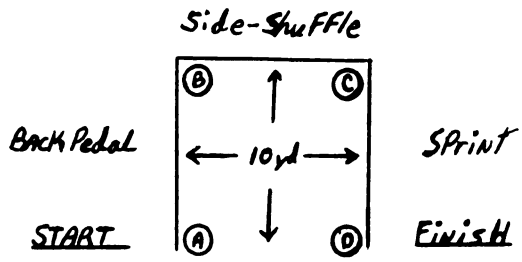
L- ANCHORS USED TO "CLOSE" TAPING, THREE ANCHORS ON THE LOWER LEG AND ONE ANCHOR PROXIMAL TO THE BASE OF THE FIFTH METATARSAL ON THE FOOT.

APPENDIX F

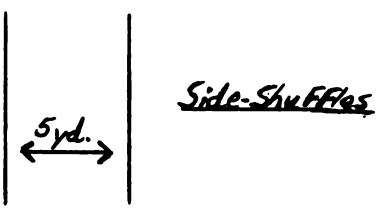
AGILITY DRILLS AND SPRINT TESTING

Agility Drills

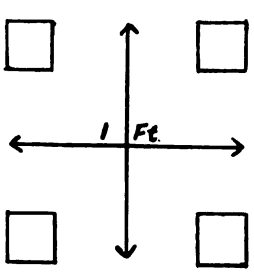
-Cone Drill: 4 cones are set up in a 10 yard by 10 yard square. The subjects backpedal from cone A to cone B, then side-shuffle to cone C, and sprint forward to cone D. This drill is performed one subject at a time. As the subject in front reaches cone B, the next subject starts the drill. The drill is performed 10 times in which the subjects are encouraged to go as fast as possible.



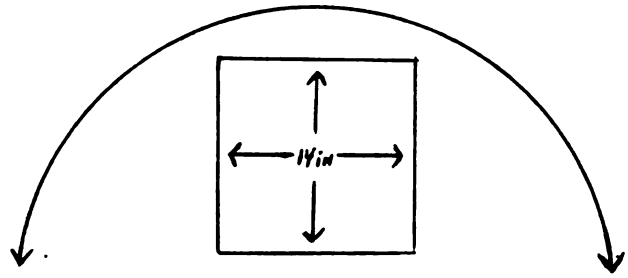
-Shuffle Drill: Each subject shuffles side to side 5 yards and back to the starting position without crossing their feet. The athletes are encouraged to do this as fast as they can for 2 minutes.



-Jumping Drill: 4 squares (4 in by 4 in) have been painted on the turf one foot apart forming a square. The subjects will jump from square to square as fast as they can for 2 minutes in a clock-wise direction. They will all follow the same pattern.



-Bag Drill: Each subject participated in 30 seconds of jumping over the bags (14 inches by 14 inches) with their feet together as fast as they could. This will be done 5 times.



-Reaction Drill: The subjects stutter step in place as fast as they can, then as the coach points a direction, forward, backward, right, or left, the subjects take 3 quick shuffle steps in that direction and continue to stutter step in place until the coach points a new direction. Three steps are taken in the new direction and the subject continues to stutter step. At the coaches discretion, the subject will sprint forward 10 yards. This drill usually lasts 20 seconds and is repeated 5 times.

Sprints

-Each subject runs ten-100 yard sprints in 14 seconds with 30 seconds rest between each sprint.

-Each subject runs eight-80 yard sprints in 12 seconds with 25 seconds rest between each sprint.

APPENDIX G

TESTING PROCEDURES FOR THE MODIFIED INMAN ANKLE TESTING MACHINE

PROTOCOL FOR THE MODIFIED INMAN ANKLE TESTING MACHINE

Positioning the Instrument.

1. The ankle testing apparatus should be used on a table large enough for both the instrument and subject.
2. The instrument is placed on the table to allow the turnstile load wheel to be positioned over the edge of the table.

Initial Calibration.

Preparing the Instrument (see Figure 3)

1. The red and black rods are clamped in place on the control panel using the red-to-red, black-to-black color scheme.
2. Turn on power to potentiometer by turning the power switch to "ON".
3. The black power switch on the side of the ECG voltmeter is turned on.
4. The 2000 amp switch on the side of the ECG voltmeter is pushed in.

FIGURE 3. ECG VOLTMETER

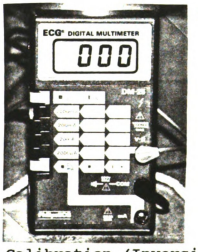
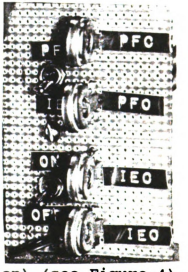


FIGURE 4. CONTROL PANEL



Turnstile Calibration (Inversion/Eversion) (see Figure 4)

1. Align the turnstile so that the calibration lines are to the sides of the locking clamp.
2. Secure the turnstile with the locking screw immediately above it.
3. Turn the calibration switch to the "IE" position (downward).
4. Calibrate the potentiometer by turning the calibration screw labeled "IEO" (bottom screw) until the first two digits from the left side read zero. Disregard the negative sign.

5. Now release the turnstile locking screw and move the turnstile clockwise until the vertical support of the swing arm stops the motion by hitting against the locking clamp. Secure the turnstile by using the locking clamp.
6. Use the calibration screw labeled "IEC" (second from the bottom) to calibrate the potentiometer to 78 degrees. Remember to read the first two digits from the left side and disregard the negative sign.

notes: Calibration screws turn right to lower the readout on the potentiometer.
Recalibration should be done between pre and post activity measurements and should not slow down the testing procedure.

Testing Preparation (see Figure 5)

1. Lock the turnstile and swingarm in the 0 position.
2. The subject should be placed on his back with the appropriate leg placed on the calf resting bar, the shank horizontal and the malleoli in line vertically with the rotation knobs. The sole of the foot should be pressed firmly against the foot pad.
3. The wooden clamp should be moved up or down the slide until the malleoli line up vertically with the rotation knobs on either side of the ankle.
4. Secure the wooden clamp into position, strap the subject's foot to the pad using the velcro straps, and make sure the clamp is secured to the subject's calcaneus.
5. The foot pad is now positioned so that an imaginary line bisecting the lateral and medial malleoli are in line with the rotation knobs on either side of the ankle.
6. Secure the calf in place using the velcro restraining strap.

Measuring Inversion/Eversion Range of Motion

1. Be certain the swing arm is raised and locked in the horizontal position.
2. The potentiometer switch should be in the "IE" reading position.
3. The turnstile locking screw should be loosened to allow for free movement.

4. The administrator stands behind the turnstile loading wheel to allow for control of the weights.
5. A loading cord is placed on the turnstile by hooking one end on the anchoring screw and following the run well so that the cord goes around the turnstile in the appropriate direction depending upon whether inversion or eversion is being measured.
6. Instruct the subject to "relax" and add the six kilogram weight to the loading cord.
7. After the weights have been added, and the subject relaxes his lower leg, record the reading on the potentiometer.
8. After the measurements have been recorded, remove the weights and loading cord.
9. Repeat steps 1 - 8 for the other leg.

Post-Measurement Activities

1. Check to see that all measurements are recorded clearly.
2. Release the calf and foot restraining straps and release the subject from the instrument.

APPENDIX H

SUBJECT RECORD SHEET

SUBJECT CODE_____

	PRE-EXERCISE	POST-EXERCISE
CONTROL		
CLOSED BASKETWEAVE		
MOLESKIN STIRRUP		
SPARTAN SLIPPER		

-ALL READING SHOULD BE REPORTED IN DEGREES

-BOTH ANKLES SHOULD HAVE SCORES FOR EACH CELL