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THE EFFECTS OF THE AIR CAST SPORTS STIRRUP ON POSTURAL SWAY IN
NORMAL MALES

by

Captain Jay Scott Cloutier

B.S., University of New England, 1985

Submitted to the Graduate Faculty
School of Health and Rehabilitative Sciences in
partial fulfillment of the requirements for the
degree of Masters of Science

University of Pittsburgh

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THE EFFECTS OF THE AIR CAST SPORTS STIRRUP ON POSTURAL SWAY IN
NORMAL MALES

Jay S. Cloutier, MS

University of Pittsburgh, 1993

The purpose of this study was to evaluate the effect of wearing the Air Cast Sports Stirrup ankle orthosis on postural sway in normal males. Twenty-two males were randomly assigned to two groups: Group I wore the Air Cast Sports Stirrup for the first three trials and then finished the test without the Air Cast Sports Stirrup, while Group II donned the Air Cast Sport Stirrup during the second three trials only. Both groups completed six, thirty second trials of single leg stance on their right leg. The resultant vectors of speed (R Speed) and amplitude (R Amp) were recorded and analyzed. A repeated measures ANOVA was performed, and no significant decreases in postural sway were found due to the brace or group assignment. A significant decrease in R Speed was noted to have occurred secondary to time ($p < 0.01$). The study found no effect of the Air Cast Sports Stirrup in decreasing postural sway.

KEY WORDS: Air Cast Sports Stirrup, Postural sway

FORWARD

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The findings of this project are the author's, and not the United States Air Force or the Department of Defense.

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I. INTRODUCTION

Ankle sprains are the most common musculoskeletal injuries seen in the emergency room today (18). They cost anywhere from 600 to 900 dollars per injury for diagnosis and proper treatment (32). Brand, Black, and Cox (6) and Weiker (59) report that most ankle sprains tend to be under-diagnosed and poorly treated. This under-diagnosis and poor treatment of the sprained ankle tends to increase the postural sway and incidence of functional instability (13,20,23).

Garn and Newton (23) found a decrease in kinesthetic awareness in subjects with recurrent ankle sprains. Freeman et al (20) found that recurrent ankle sprains had higher rates of instability. Increased postural sway increases the instability of the ankle (13).

Postural sway is the magnitude of body sway during quiet stance (13). Stabilization of the body during sway is controlled by the ankle (46). Balance is maintained by visual cues, vestibular control, cutaneous input, muscle receptors and joint receptors (23). When an inversion sprain occurs, tearing of the ligaments also occur, which results in deafferentization of the articular nerves (20).

Several treatment modalities are available in treating the sprained ankle in an attempt to improve proprioceptive and balance of the ankle. Some researchers advocate the use of the Air Cast in the management of the lateral ankle sprain (42, 53). Barrett, Cobb, and Bentley (1) found increased joint position sense increased when an ace wrap was applied around the subjects knee. They theorize this increased joint sense was due to cutaneous input and may account for the justification for wearing of ace wraps, braces, and tape to make the body part more "stable". Walsh and Blackburn (58) state that taping and bracing are used for the prevention of ankle sprains. Friden, Zatterstrom, Lindstrand, and Mortiz (22) state that wearing the Air Cast on a sprained ankle decreased postural sway. To date, no studies have been performed to study the effects of wearing the Air Cast Sports Stirrup on normal ankles for the means of prevention of injury.

Prevention of ankle sprains is the key to avoiding sprained ankles. Currently ankle prophylaxis takes the form of taping, the use of ankle orthoses, exercises, and proper shoe fitting (58). Ankle taping is universally accepted as a prophylaxis without a decrease in athletic performance (9). After exercise

the ankle tape is loose ,providing the ankle with only limited protection (36). Others found that ankle taping loses 40 percent of its strength after 10 minutes of exercise, and that after one hour, there is no significant support (30). DeMaio, Paine and Drez (15) found that ankle orthoses have been more effective than shoe type or taping in the prevention of ankle sprains, while others advocate the use of ankle orthoses as an alternative to taping, as taping is expensive and is difficult to learn (56).

The Air Cast is the preferred orthoses in the management of ankle sprains (53). Stover (53) found the Air Cast was an effective alternative to ankle taping. The Air Cast was found to be stronger in resisting inversion and did not weaken during or after exercise in resisting inversion (30). Several universities such as Duquesne University in Pittsburgh, PA, and the University of Michigan routinely tape their men's basketball team in an attempt to prevent ankle sprains.

Sitler (43) found ankle sprain incidence dropped from 5.2 per 1000 to 1.6 per 1000 with the use of the Air Cast Sports Stirrup on West Point intramural basketball players. His subjects had no ankle injuries prior to the study. He recommends the use of the Air

Cast Sports Stirrup as a prophylaxis for ankle sprains. Gross et al, (31) found using Air Cast Sport Stirrup application nine times more comfortable than regular taping. In addition, taping technique is difficult to learn and is not cost effective if used for prophylaxis. In contrast, the Air Cast Sports Stirrup is easy to use and is effective in preventing ankle sprains (50,53). The purpose of this study is to identify changes in postural sway while wearing the Air Cast Sports Stirrup.

II. REVIEW OF THE LITERATURE

A. Incidence

Ankle injuries are the most common injuries that occur in sports. Out of 4673 patients treated for sports related injuries at an Oslo Emergency Clinic, 16 percent had an ankle sprain (18). Garrick (24) states that the ankle is unique in that the vast majority (85 percent) of ankle injuries are sprains that involve the lateral structures. He also reported that in the National Football League, the ankle was involved in over 10 percent of the time loss injuries (24).

Garrick (24) reports that 14 percent of all participants in sports will have an injury involving the ankle. The rate of occurrence was 6 per 100 participants, and 85 percent of them were ankle sprains. Ankle sprains remain a major threat to participation in sports today. Bortua, Bishop, Braly, and Tullos (5) report that ankle sprains produce 25 percent of the time loss in sporting events.

Ankle sprains are a costly injury. Hergenroeder (32) reported 1 million people present with acute ankle injuries per year with an average cost of 300 to 900 dollars for adequate diagnosis and rehabilitation.

Brand, Black, and Cox (6) and Weiker (59) report that ankle sprains tend to be the most under-diagnosed and poorly treated injury in the United States today. This under-diagnosis and improper treatment of ankle sprains leads to a higher incidence of chronic ankle instability (20,23).

B. Postural Sway

Granat, Barnett, Kirkwood, and Andrews (29) define postural sway (PS) as the movement of the center of pressure of the subject while standing on a force platform, including the mean radius of travel and speed of sway. Operationally, Lederer (40) defines PS as the amplitude and speed of sway in an anterior-posterior and medial-lateral direction away from the center of pressure while the subject is standing on a force platform.

Normal stance is maintained against the destabilizing effect of gravity by reflexive neural pathways (17). Nashner (46) found that the ankle joint provides the major contribution to stabilize PS. Gordan (28) found balance is usually maintained by a tonic contraction of the soleus. Position is monitored by more than just joint receptors; muscle and skin receptors also are involved (20).

C. Proprioception

Proprioception/kinesthesia is the ability to discriminate joint motion and position, and decreased kinesthetic awareness is caused by de-afferentization of joint receptors (23). The kinesthetic component is comprised of input from muscle receptors, (the golgi tendon organ [GTO] and the muscle spindle), cutaneous input, and from the joint receptors (1,20,23,27). The joint receptors are found in the superficial and deep layers of the joint capsule and ligaments (21). Kinesthesia provides reflex stabilization of the leg muscles to maintain balance (47).

Freeman and Wyke (21) classified the joint receptors into four categories. Type I are low threshold and slow adapting and are found in the stratum of the capsule. They are active during static and dynamic moment. Type II joint receptors are located at the junction of the synovial membrane and the fibrosum layer of the joint capsule and fat pads. They have a low threshold for activation, are rapid adapters, and are activated at the onset of and termination of movement. Type III joint receptors are found in the collateral ligaments and are GTO type capsules. They have a high threshold for activation,

are slow adapting, and are active at the end range of movement. They are responsible for detecting the position and direction of the movement. Type IV joint receptors are free nerve endings that respond to noxious stimuli (20,47). Newton (47) suggests that Type III joint receptors fire at the end range of movement, and the muscle spindle fires to detect motion in the intermediate ranges.

Articular nerve fibers have lower tensile strength than collagen fibers (21). Since most inversion injuries of the ankle result in some tearing of the ligaments, it is also enough force to tear the articular nerve fibers (5,20).

De-afferentization of the articular nerves, partial or full, results from a traction type injury that tears the ligaments and may be permanent. This permanent de-afferentization interferes with the normal reflexive responses around the ankle and may give the feeling of giving way (8,20). A significant delay in peroneal reaction time in ankles that had been sprained previously has been seen, and is thought to be caused by this de-afferentization (38).

Joint receptors have an influence on postural and locomotor patterns, but control of the joint motion is found in the muscle spindle (39). The greater the

density of muscle spindle, the finer the control of movement (39). Clark, Burgess, and Chapin (11) found greater position sense input comes from the muscle receptors and cutaneous input, and that joint receptors are better at detecting rapid movements rather than slower movements.

Garn and Newton (23) and Freeman et al (20) found proprioceptive deficits decreased if patients exercised their sprained ankles to increase strength and coordination. McCloskey (41) and Garn and Newton (23) found a redundant system (through the muscle spindles, GTO, and cutaneous input) were in place for maintaining postural reflexes once the articular joint receptors were anesthetized. Overcoming increases in postural sway secondary to inversion sprains may be accomplished by utilizing braces such as the Air Cast and exercises designed to increase balance and coordination (1,41). This study attempted to analyze the effect of the Air Cast Sports Stirrup on postural sway in normal subjects, as the Air Cast Sport Stirrup advocated its use as a prophylactic ankle orthosis.

D. Factors Effecting Postural Sway

Postural sway has been found to increase as the body ages, and is associated with the general slowing of cognitive motor responses with advancing age (54). In related studies, others have found that elderly individuals have higher proprioceptive thresholds to passive movements than the young (3,52). Crilly, Willems, Trenholm, Hayes, and Delaquerriere-Richardson (12) found that exercises were not beneficial in improving PS after the nervous system deteriorated in the elderly subjects. Skinner et al. (52) theorize that this higher proprioceptive threshold leads to increased incidence of falling seen in the elderly.

Murrell, Cornwall, and Doucet (45) found that leg length did not have an impact on PS. Cornwall and Murrell (13) found increased PS in subjects with multiple ankle sprains. This study excluded those who sustained a sprained ankle within the last year, while leg length discrepancies may not automatically eliminate a subject.

Overstall, Exton-Smith, Imms, and Johnson (49) found differences in amplitude of sway based on gender. They found an increase in the amplitude of sway in females. Walsh (57) found no intra-variability between

males and females in postural sway, and that postural sway did not differ in subjects from day to day.

E. Treatment of Sprained Ankles

Treatment of the sprained ankle has ranged from total immobilization to exercise and minimal bracing (42). Several studies have advocated the use of the Air Cast in controlling inversion stresses while still allowing the patient to ambulate normally during the healing time after an ankle sprain (30,33,37). Friden, Zatterstrom, Lindstrand, and Mortiz (22) found that the Air Cast decreased PS on an injured ankle when compared to the ankle without the Air Cast.

F. Prevention of Ankle Sprains

Prevention of ankle sprains has been the best way to avoid an ankle sprain. DeMaio, Paine and Drez (15) found orthoses more effective than shoe type or taping. Tropp, Askling, and Gillquist (56) advocated the use of ankle orthoses as an alternative to taping, as taping is expensive and is difficult to learn. Others have advocated using elastic supports for prophylactic use only after posturographic examination, because of differences in individual's postural equilibrium (10). Karlsson and Andreasson (36) found taping restricted

the extremes of motion and helped to shorten the reaction time of the peroneus muscles, thus increasing proprioceptive function of the ankle. Their study failed to test the ankle in functional activities and relied on stress tests to validate their findings.

Tropp and Askling (56) and Freeman et al. (20) found ankle exercises emphasizing proprioception exercises decreased the PS, and the subject's balance improved. Orteza, Vogelback, and Denegar (48) found decreased PS times when a molded orthotic was inserted in the subjects shoe after an ankle sprain.

The Air Cast Sports Stirrup has been marketed as an alternative to taping in the prevention of ankle sprains. The use of the Air Cast Sport Stirrup provides a more comfortable fit and offers better stability than taping as a prophylaxis to ankle sprains (30). No studies have examined the effects of wearing the Air Cast Sport Stirrup on postural sway. The purpose of this study was to determine the effects of the Air Cast Sports Stirrup brace on PS in healthy male adults with no pathology of ankle injuries.

G. Hypothesis

This study attempts to determine what effect wearing an Air Cast Sports Stirrup has on resultant speed vector (speed R) and resultant amplitude vector (amp R) of sway. It is hypothesized that the wearing of the Air Cast Sports Stirrup would decrease the speed R and the Amp R of sway (PS), in normal, healthy, athletic males when they stood on their right leg.

III. METHODOLOGY

A. Subject Characteristics

Twenty-two male subjects between the ages of 18-29 who met the eligibility criteria and volunteered were used in this study. Subjects completed a health questionnaire (Appendix A) and signed the letter of consent approved by University of Pittsburgh Biomedical Review Board (Appendix B).

Criteria for enrollment in this study included the absence of lower extremity pathology or injury in the last 12 months, the lack of known balance disorders, the ability to perform single leg stance without pain, and the absence of alcohol or medications taken within the last 24 hours which might have affected their balance.

B. Apparatus

A Kistler Static Force Platform interfaced with a Casper personal computer was used to calculate the resultant vector of each sway parameter: amplitude of sway and the speed of sway. The resultant vector was the vector or direction of movement that was formed

when the movement along two axes were added together. The outputs from four vertical sensors located on the corners of the platform were sampled 20 times per second by the computer. The examiner had a thumb switch to press if the subject was unable to complete the 30 second trial. This marked the time that the subject deviated from the testing position.

The Air Cast Sports Stirrup brace was utilized. The standard Air Cast Stirrup brace consists of two plastic shells that are lined with adjustable air bladders and approximate the ankle medially and laterally with an adjustable heel pad and two Velcro straps connecting the shells. This design has been shown to effectively reduce inversion and eversion range of motion before, during, and after exercise (19,31,37). The Air Cast Sports Stirrup brace was engineered to prevent ankle sprains by being designed for the unswollen ankle with narrower shells to provide a better fit in the shoe, and the same support as the standard Air Cast (31) (Figure 1).

C. Dependent Variable Measurements

Postural sway (PS) was defined as the movement of the center of pressure of the subject standing on a force platform, in both direction and speed (27).

Operationally, PS was defined as the amplitude and speed of sway in an anterior-posterior and a medial-lateral direction away from the center of pressure while the subject was standing on a force plate (40).

The amplitude of sway was calculated by the computer as the resultant vector (R) from the deviations from the center of pressure on the X and Y axes, where X was the deviation in the medial/lateral direction, and Y was the deviation in the anterior/posterior direction. The speed of sway was calculated by the computer as the resultant vector for the speed of sway along the X and Y axes where the X axis was the speed in a medial/lateral direction, and the Y axis was the speed in an anterior/posterior direction.

D. Testing Procedures

Each subject performed six (6), thirty (30) second trials of single leg stance on their right leg to assure standardization of testing procedure. The subject stood on the center of the Kistler force platform. The single leg stance position the subjects were required to maintain is described as standing on their right leg, left leg flexed, arms folded, and eyes that are open and looking straight ahead (Figure 2). A custom built picture was placed at eye level for the

subject to focus on. Each subject was provided verbal instructions, plus had the proper testing position demonstrated. No practice trials were allowed.

Three trials were performed while wearing a standard Air Cast Sport Stirrup (Air Cast, Inc., P.O. Box 709, Summit, NJ, 07902-0709) (Figure 3) on their right ankle; while the other three trials the subject did not wear the Air Cast Sports Stirrup. Both groups wore their own low top court sneaker during testing. The Air Cast Sports Stirrup was placed on the subject's ankle by the examiner according to the manufacturer's instructions. The subjects shoes were tied by the examiner to get a uniform and consistent tension on the snugness of the laces for both trials. The subjects were randomized into two groups. Group I performed three trials with the Air Cast Sport Stirrup (ACSS) first, followed by three trials without the Air Cast Sport Stirrup; group II underwent three trials without the Air Cast Sports Stirrup, followed by three trials with the Air Cast Sports Stirrup. Each trial lasted thirty (30) seconds, with a one (1) minute rest period between bouts to help eliminate the symptoms of fatigue. A trial was terminated if the subject touched the ground with their opposite foot, unfolded their arms, or if they hopped on their stance foot. The

subject was allowed to repeat one trial if they deviated from the position. Only one retrial was allowed during the entire test.

E. Reliability

The reliability of the Kistler Force platform is well documented (4,27,35). Thyssen, Brynskor, Jansen, and Munster-Swendsen (55) found no significant differences in test-retest reliability over five (5) consecutive days. These studies lend credibility and reliability for the use of the mean of three trials and the use of the Kistler force platform as the test instrument.

F. Research Design

This study was of 2 X 2 X 3 factorial design and was experimental in nature as there was randomization of a treatment (the Air Cast Sports Stirrup) and group assignment. There were two (2) dependent variables: R amplitude and R speed of sway. The independent variable was the use of the Air Cast Sports Stirrup. The three factors were the group assignment (Group I or Group II), the condition (either Air Cast Sports Stirrup [ACSS] brace or no Air Cast Sports Stirrup [NACSS] brace), and the three trials per each condition.

G. Statistical Analysis

The individual trial values of the R amplitude and R speed of sway for each subject with the Air Cast Sports Stirrup and without the Air Cast Sports Stirrup were compared. An Intraclass Correlation was performed to determine the reliability of using the mean in the statistical analysis (2,1) (51). This version of the ICC was used because there was one rater, and the trials were considered to be randomly sampled. If the ICC value was greater than $r > .70$, then the means would be used, but if $r < .70$, the individual trials would be compared. A Repeated Measures ANOVA (BMDP Statistical Software, Inc., 1440 Sepulveda Blvd, Los Angeles, CA 90025) was used because this method took into account more than one factor and examined the interactions between three factors: group assignment, the condition (either brace or no brace), and the three trials for each condition. Statistical significance was set at $p < .01$. A Tukey post-hoc analysis was also used to determine if the means of the six trials differed significantly from one another, and to determine which trial was significant (26).

IV. RESULTS

A total of 22 male subjects consented to participate in the study. The subjects were randomized into two equal groups ($n=11$). A summary of the means and standard deviations for age, height, weight and activity level for each group of subjects are included on Table 1. Ages were similar for both groups with a mean of 20.5 ± 3.1 years for Group I and 20.9 ± 2.3 for Group II. Height was also similar with a mean of 70.7 ± 2.1 inches for Group I and 71.3 ± 2.8 inches for Group II. Group I weighed more than Group II (165.1 ± 23.3 pounds versus 170 ± 27.2 pounds). Group I was also more active than Group II (13.3 ± 2.7 hours per week compared to 9.0 ± 3.5 hours per week). The individual subject characteristics for Group I and Group II are seen in Tables 2 and 3.

The resultant vector for speed of sway (R Speed) and amplitude of sway (R Amp) was calculated by the computer and recorded for each trial. The three trials for each condition was used after ICC's (2,1) were calculated, and 2 trials were found to be below $r=.70$ (51). This low reliability of ICC's did not allow the use of means for subjects per each condition, and required the use of individual trials in the ANOVA. The

ICC's for each group, trial, and condition are located in Table 4 and 5. Raw data scores for each trial, condition, and group are located in Tables 6-9.

A. Speed of Sway (R Speed)

An ANOVA with repeated measures with group assignment, condition, and trials as factors was used. The interaction of three factors: group selection, condition, and the three trials for each condition was analyzed. Results are found in Table 10.

There was no statistical difference for all subjects between the ACSS brace and NACSS brace condition ($p < .01$). There was a statistically significant difference among the six trials regardless of group or condition (Table 10). A Tukey post-hoc test showed a significant decrease between trial 1 and trials 2, 3, 5, and 6 (minimum significant difference = .2553). Trial 1 and trial 4 were not statistically different and may be secondary to the change in condition (either ACSS to no ACSS and visa versa). The group assignment or ACSS condition did not effect the decreases in R Speed in the six trials. The decrease in R Speed were caused by conducting the trials over time (Tables 11-12) (Figure 4).

The results showed a significant decrease in R speed from trial 1 to trial 2, 3, 5, and 6. The ANOVA was re-run to identify outliers that gave skewed results, and look at their effect on the original results. The ANOVA was re-run without the first trial and showed no statistical significance between trials over time (Table 13).

B. Amplitude of Sway (R Amp)

The R Amp analysis demonstrated no significance ($p < .01$) in group differences, differences in condition, or changes over the six trials (Table 14).

V. Discussion

A. Findings

This study was designed to test the hypothesis that the use of the Air Cast Sports Stirrup would decrease R Speed and R Amp (components of postural sway) in ankles of normal males. There was no significant difference in R Speed or R Amp when the use of the Air Cast Sports Stirrup was compared to trials without the Air Cast Sports Stirrup. This lack of statistical significance allows for the rejection of the hypothesis, and the acceptance of the null hypothesis.

The results of this study confirm the findings of other studies which found no significant differences in sway patterns when a brace was used with patients with hemiplegia (43). Sway values including speed and amplitude obtained in this study are similar to other studies of normal sway (2,13,57).

The results of this study contradicted the findings by Feuerbach and Grabiner (19) which found a decrease in sway variables (speed and amp) with the use of the Air Cast brace. The differences in the conditions of this study compared to those of Feurbach and Grabiner include used the anterior/posterior and

medial/lateral sway amplitude and frequency variables rather than the resultant vectors. Also, they did not use center of pressure measures but percentage of body weight deviated from the mean relative loading which was calculated from the horizontal moment and vertical force data generated by triaxial force platforms. They utilized the standard Air Cast Stirrup and not the Air Cast Sports Stirrup.

Feuerbach and Grabiner (19) raised the possibility of using the Air Cast as a prophylactic device in reducing the incidence of ankle injuries. They suggested the possibility of enhanced afferent feedback to explain why the Air Cast decreased sway. This current study did not support this theory nor their findings.

The data demonstrated a decreased R Speed from Trial 1 to Trial 6. The results illustrated that the decrease in R Speed was not due to the wearing of the Air Cast Sports Stirrup or by group assignment, but was significant over time.

The difference over time may have been caused by a learning effect by the subjects or by fatigue. The subjects in this study were not given practice opportunities before the data was collected. DeCarlo and Talbot (14) found similar results in their study.

They tested each subject's sway five times and then injected each subjects ankle with an anesthetic. They then re-tested each subjects sway an additional five repetitions. Each subject received a total of ten 30 second trials, with one minute rest between trials. They also gave the subjects a one minute warm up period prior to the pre-test, and found a statistically significant difference between trials within subjects which was attributed to a learning response by the subjects.

The lack of a warm up period in this study may explain the difference in R Speed in trial 1 to trials 2,3,5,and 6. It may be that the higher values in R Speed for Trial 1 were caused by the subject becoming accustomed to the position and apparatus. If a warm up period was given, the results may have been similar to the remaining trials, and the decrease would not have been significant as seen in Table 13, which analyzed the effect of the trials on R Speed without Trial 1.

The lack of a significant decrease in R Amp may be attributed to the Air Cast Sports Stirrup or the shoe limiting the amount of motion at the ankle (30,31,37). R amp was the amount of displacement from the center of pressure and could have remained consistent even though the speed required to displace would vary.

B. Implications

Several studies advocate the use of ankle orthoses in preventing recurrent ankle sprains without a decrease in athletic performance skills (i.e. jumping, running, and cutting) (9,10,37,53). Sitler (50) and Feuerbach and Grabiner (19) recommend the use of the Air Cast Sports Stirrup for the prevention of ankle injuries in healthy subjects. Feuerbach and Grabiner (19) theorize that the Air Cast controls, among other factors, postural sway. Increased postural sway has been characterized as a cause for increased incidence of falls in the elderly and for increased incidence of ankle sprains (13,22,25,52). The mechanism for the success of the Air Cast Sports Stirrup may be secondary to controlled inversion (19,37) and not due to postural sway being decreased. The results of this study do not support the theory that wearing of the Air Cast Sports Stirrup decreases postural sway in healthy subjects.

C. Limitations of Study

The sample was one of convenience. All subjects were collegiate athletes and may not be a representative sample of the general population due to their abilities; however, this group may be indicative of a more active population.

D. Implications for Future Research

A future study should be designed to determine if a learning effect occurs over trials. Subjects could be tested over a series of trials with a practice trial given and then later retested to determine their retention of the skill. It would also be useful to be able to test subjects in a more dynamic activity while using the Air Cast Sports Stirrup. A psychological index could also be incorporated to determine security or safety perceptions of the Air Cast Sports Stirrup. Shoe type could also be considered as a variable in a future study of this subject.

VI. Conclusion.

The effect of wearing the Air Cast Sports Stirrup on R Amp and R Speed of sway was studied. This study failed to demonstrate a significant impact of the Air Cast Sports Stirrup on postural sway. There was a decrease in R Speed over trials, which may indicate a learning effect took place. The use of the Air Cast Sports Stirrup may be effective in preventing ankle sprains, but based on the findings of this study, postural sway does not appear to be the major factor in the effectiveness of the Air cast Sports Stirrup in normal, healthy males

APPENDIX A
Health Questionnaire

NAME _____ AGE _____

HEIGHT _____ WEIGHT _____

OCCUPATION _____

How many hours per week do you participate in physical activity?

0-4 4-8 8-12 12-16 16+

Type: _____

Have you had any of the following in the last 12 months?

- | | | |
|---|-----|----|
| 1. Sprained Ankles | YES | NO |
| 2. Broken bones in the thigh | YES | NO |
| 3. Broken bones in the leg | YES | NO |
| 4. Broken bones in the foot | YES | NO |
| 5. Ankle/foot injuries | YES | NO |
| 6. Shin Pain | YES | NO |
| 7. Knee injuries | YES | NO |
| 8. Low back pain requiring medical treatment | YES | NO |
| 9. Hip injuries | YES | NO |
| 10. Other injuries or problems to your legs | YES | NO |
| 11. Have you consumed alcohol within the last 24 hours? | YES | NO |

12. Are you currently taking any medications
on a regular basis? If yes, YES NO
Type_____

13. Do you have any problems with balance? YES NO
Explain._____

14. Cold/Sinus/Inner ear infections currently YES NO

15. Do you have any other medical condition
not listed above? YES NO

Explain. _____

16. Comments.

APPENDIX B



University of Pittsburgh

SCHOOL OF HEALTH AND REHABILITATION SCIENCES
Department of Physical Therapy

12 Jan 93 approved Biomedical
IRB, University of Pittsburgh

Consent to Act as a Subject in a Clinical Study

The Effects of the Air Cast Sports Stirrup on Postural Sway in
Normal Subjects

JAY S. CLOUTIER, CAPT, USAF, BSC
68 East West Drive
Pittsburgh, PA 15237
1-412-931-3892

DESCRIPTION: This study is being undertaken to evaluate what
effect wearing an Air Cast Sports Stirrup on your ankle will have
on your balance. You will be asked to stand six times on your
right leg and stand as steady as possible for 30 seconds.

Subject's Initials

You will be asked to wear an Air Cast Sports Stirrup three of the six times you are asked to stand; The other three times, you will be asked not to wear the Air Cast Sports Stirrup. You will stand on a force platform where your "sway" will be measured. Sway is the amount of motion you move while standing still. You will be asked to wear comfortable clothing and wear a pair of court sneakers.

RISKS AND BENEFITS: There are minimal risks in this study. You might not be able to stand for the full 30 seconds. A physical therapist will stand beside you at all times. This study may help health care providers to have a better understanding of balance and postural sway in patients with ankle sprains.

COSTS AND PAYMENTS: No costs will be incurred by you, the subject, and you will receive no monetary compensation for participating in this study.

Subject's Initials

CONFIDENTIALITY: I understand that any information about me obtained from this research, including answers to questionnaire, history, and findings on physical examination will be kept confidential. I do understand that research records, like medical records, may be subpoenaed by court order. It has been explained to me that my identity will not be revealed in any description or publication of this research. Therefore, I consent to such use of my test results for scientific purposes.

RIGHT TO WITHDRAW: I understand that I am free to participate in this study or to withdraw at any time, and that I must inform the researcher of my withdrawal. I also understand that the investigator may require that I withdraw from this study if I fail to meet the eligibility criteria.

COMPENSATION FOR ILLNESS OR INJURY: I understand that in the event of a physical injury or illness resulting from the research procedure that no monetary compensation will be made.

Subject's Initials

VOLUNTARY CONSENT: I certify that I have read the information of the preceding pages or it has been read to me, and I understand its contents. Any questions I have pertaining to the research have been, and will be answered. A copy of this consent form will be given to me after I have signed both copies. My signature below means that I have freely agreed to participate in this experimental study.

Date

Subject's Signature

Witness

INVESTIGATORS CERTIFICATION: I declare that I have personally explained the above information to the subject or the subject's legal representative.

Date

Investigator's Signature

Witness

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Table 1. Mean age, height, weight, and activity characteristics of the Air Cast Sports Stirrup(ACSS) and non-Air Cast Sports Stirrup (NACSS) groups.

	ACSS		NACSS	
	<u>Mean</u>	<u>S.D.</u>	<u>Mean</u>	<u>S.D.</u>
Age (yrs)	20.5	3.1	20.9	2.3
Height (inches)	70.7	2.1	71.3	2.8
Weight (lbs)	165.1	23.3	170.0	27.2

Activity level (hrs/wk)

	<u>0-4</u>	<u>4-8</u>	<u>8-12</u>	<u>12-16</u>	<u>16+</u>
ACSS Group	0	0	4	3	4
NACSS Group	0	5	4	1	1

Table 2. Subject data including age, height, weight, and activity characteristics of the Air Cast Sports Stirrup group.

Age (yrs)	Hgt (in)	Wgt (lbs)	Activity level (hrs)
20	70.0	188	12-16
19	72.0	190	12-16
18	73.0	145	16+
18	72.0	179	16+
21	70.5	165	8-12
20	68.0	130	12-16
18	73.0	154	8-12
20	66.0	125	8-12
29	71.0	180	8-12
21	70.0	175	16+
21	72.0	185	16+

Mean and SD: Age (yrs) 20.5 $\pm$ 3.1
 Height (in) 70.7 $\pm$ 2.1
 Weight (lbs) 165.1 $\pm$ 23.3

Table 3. Subject data including age, height, weight, and activity characteristics of the non Air Cast Sports Stirrup group.

Age (yrs)	Hgt (in)	Wgt (lbs)	Activity level (hrs)
19	73.0	170	4-8
18	67.0	145	4-8
22	71.0	200	4-8
23	68.0	130	8-12
19	72.0	200	16+
20	74.0	188	4-8
21	67.0	153	12-16
22	73.0	165	8-12
25	74.5	215	4-8
23	74.0	160	8-12
18	71.0	145	8-12

Mean and SD: Age (yrs) 20.9 $\pm$ 2.3
 Height (in) 71.3 $\pm$ 2.8
 Weight (lbs) 170 $\pm$ 27.2

Table 4. ICC values for the Air Cast Sports Stirrup group for each trial and condition.

	<u>With ACSS</u>	<u>Without ACSS</u>
R Speed	0.88	0.92
R Amp	0.90	0.59

Practical significance designated at $r > .70$.

Table 5. ICC values of the non-Air Cast Sports Stirrup group for each trial and condition.

	With ACSS	Without ACSS
R Speed	0.94	0.53
R Amp	0.82	0.71

Practical significance designated at $r > .70$.

Table 6. Resultant Speed (R Speed) values, with and without the Air Cast Sports Stirrup, of those who wore the Air Cast Sports Stirrup for the first three trials.

Subject	With Air Cast			Without Air Cast			SD*
	<u>Trial</u>			<u>Trial</u>			
	1	2	3	4	5	6	
1	2.69	2.74	3.07	2.92	3.74	3.65	.46
2	2.10	1.96	1.77	1.72	1.84	1.89	.14
3	3.55	2.91	2.89	3.57	3.43	2.70	.38
4	3.26	3.02	2.64	2.72	2.79	2.57	.26
5	3.02	2.52	2.63	2.50	2.57	2.20	.26
6	3.08	2.88	3.35	3.27	3.29	2.63	.28
7	3.25	3.19	2.93	3.24	2.87	2.99	.17
8	3.29	2.96	3.22	3.11	3.30	2.79	.20
9	2.67	2.80	2.66	2.60	2.45	3.07	.21
10	3.09	2.54	2.40	2.72	2.50	2.00	.36
11	3.63	3.68	3.94	3.44	3.76	3.50	.18
SD**	.44	.43	.56	.52	.60	.56	

* Standard deviations for each subject over all six trials.

** Standard deviations for all subjects for each trial.

Table 7. Resultant Amplitude (R Amp) values, with and without the Air Cast Sports Stirrup, for those who wore the Air Cast Sports Stirrup for the first three trials.

Subject	With Air Cast			Without Air Cast			SD*
	<u>Trial</u>			<u>Trial</u>			
	1	2	3	4	5	6	
1	.57	.52	.74	.62	.83	.73	.12
2	.52	.73	.60	.74	.48	.66	.11
3	.69	.80	.67	.66	.75	.74	.05
4	.94	1.02	1.30	1.39	.77	.87	.25
5	.58	.57	.59	.49	.72	.55	.08
6	.78	.86	1.00	.92	.94	.92	.08
7	.79	1.00	.75	1.14	.78	1.05	.17
8	.74	.87	.83	.61	.59	.69	.11
9	.60	.55	.78	.64	.62	.72	.08
10	.78	.65	1.12	.83	.73	.88	.16
11	.93	.78	.93	.86	.97	.88	.07
SD**	.14	.17	.22	.26	.14	.14	

* Standard deviations for each subject over all six trials.

** Standard deviations for all subjects for each trial.

Table 8. Resultant Speed (R Speed) values, with and without the Air Cast Sports Stirrup, for those who wore the Air Cast Sports Stirrup for the second three trials.

	Without Air Cast			With Air Cast			
	<u>Trial</u>			<u>Trial</u>			
	1	2	3	4	5	6	SD*
Subject							
1	3.55	2.54	3.44	3.38	3.58	3.72	.42
2	3.56	3.84	3.13	3.59	3.00	2.98	.36
3	3.10	2.96	3.19	3.55	3.29	3.20	.20
4	2.80	2.72	2.38	2.56	2.24	2.61	.21
5	3.66	2.76	2.98	2.52	2.48	2.52	.45
6	4.15	2.96	2.49	2.96	2.82	3.07	.56
7	3.12	3.03	3.30	3.35	3.44	3.13	.16
8	2.29	2.41	2.43	1.81	2.08	1.78	.29
9	4.24	4.17	3.61	3.30	3.58	3.39	.40
10	3.02	2.80	2.89	2.68	2.54	2.44	.22
11	3.05	2.73	2.89	3.17	2.75	3.10	.19
SD**	.58	.54	.41	.55	.53	.53	

* Standard deviations for each subject over all six trials.

** Standard deviations for all subjects for each trial.

Table 9. Resultant Amplitude (R Amp) values, with and without the Air Cast Sports Stirrup, for those who wore the Air Cast Sports Stirrup for the second three trials.

Subject	Without Air Cast			With Air Cast			SD*
	<u>Trial</u>			<u>Trial</u>			
	1	2	3	4	5	6	
1	.80	.52	.89	1.01	.68	.84	.17
2	.73	.85	.77	.94	.85	.61	.11
3	.82	.96	.95	.97	1.01	.74	.10
4	.48	.56	.68	.48	.42	.51	.09
5	.94	.71	.89	.77	.79	.83	.08
6	.78	.71	.80	.81	.70	.70	.05
7	1.02	.79	1.14	1.43	.98	.74	.25
8	.68	.92	1.14	.75	.79	.57	.20
9	.93	.93	.81	.76	.75	.77	.08
10	.77	.77	.91	.68	.71	.86	.09
11	.60	.63	.87	.67	.71	.80	.10
SD**	.16	.15	.14	.25	.16	.12	

* Standard deviations for each subject over all six trials.

** Standard deviations for all subjects for each trial.

Table 10. The ANOVA table for the interaction of group assignment, ACSS condition, and trials for R Speed.

Source	df	SS	MS	F	p value
ACSS to no ACSS	1	0.10	0.10	0.70	.414
ACSS/NACSS X Groups (G)	1	0.43	0.43	0.09	.094
Trials (T)	2	0.92	0.46	6.23	.004*
T X G	2	0.11	0.05	0.74	.485
ACSS/NACSS X T	2	0.13	0.60	0.92	.409
ACSS/NACSS X T X G	2	0.37	0.19	2.63	.085

* Indicates significance at $p < .01$.

Table 11. Means and SDs of R Speed and R Amp for six trials when the subjects were analyzed together (n=22).

Trial	Mean R Speed	Mean R Amp
1	3.19 ± .52	0.71 ± .21
2	2.91 ± .48	0.74 ± .19
3	2.92 ± .48	0.83 ± .26
4	2.94 ± .52	0.75 ± .34
5	2.92 ± .55	0.74 ± .19
6	2.81 ± .54	0.71 ± .20

Table 12. The ANOVA table for the effect of the trials on R Speed.

<u>Source</u>	<u>df</u>	<u>SS</u>	<u>MS</u>	<u>F</u>	<u>p value</u>
Subjects	21	24.89	1.19		
Trial	5	1.73	0.35	4.06	.002*
Subject X Trial	105	8.93	0.09		

* Indicates significance at $p < .01$.

Table 13. The ANOVA table for the effect of trials on R Speed with Trial 1 deleted.

Source	df	SS	MS	F	p value
Subjects	21	22.00	1.05		
Trial	4	0.22	0.05	0.75	0.56

Table 14. The ANOVA table for the interaction of group assignment, ACSS condition, and trials for R Amp.

Source	df	SS	MS	F	p values
ACSS/NACSS	1	0.001	0.001	0.05	.82
ACSS/NACSS to Group (G)	1	0.025	0.025	0.95	.34
Trials (T)	2	0.055	0.027	0.65	.53
T X G	2	0.077	0.038	0.92	.41
ACSS/NACSS X T	2	0.042	0.021	0.79	.46
ACSS/NACSS X T X G	2	0.137	0.069	2.61	.09



Figure 1. The Air Cast Sports Stirrup and the standard Air Cast.



Figure 2. Single stance position used for testing each subject.



Figure 3. Position of subject wearing the Air Cast Sports Stirrup during testing of postural sway in single leg stance.

Means of R Speed Six Trials (n=22)

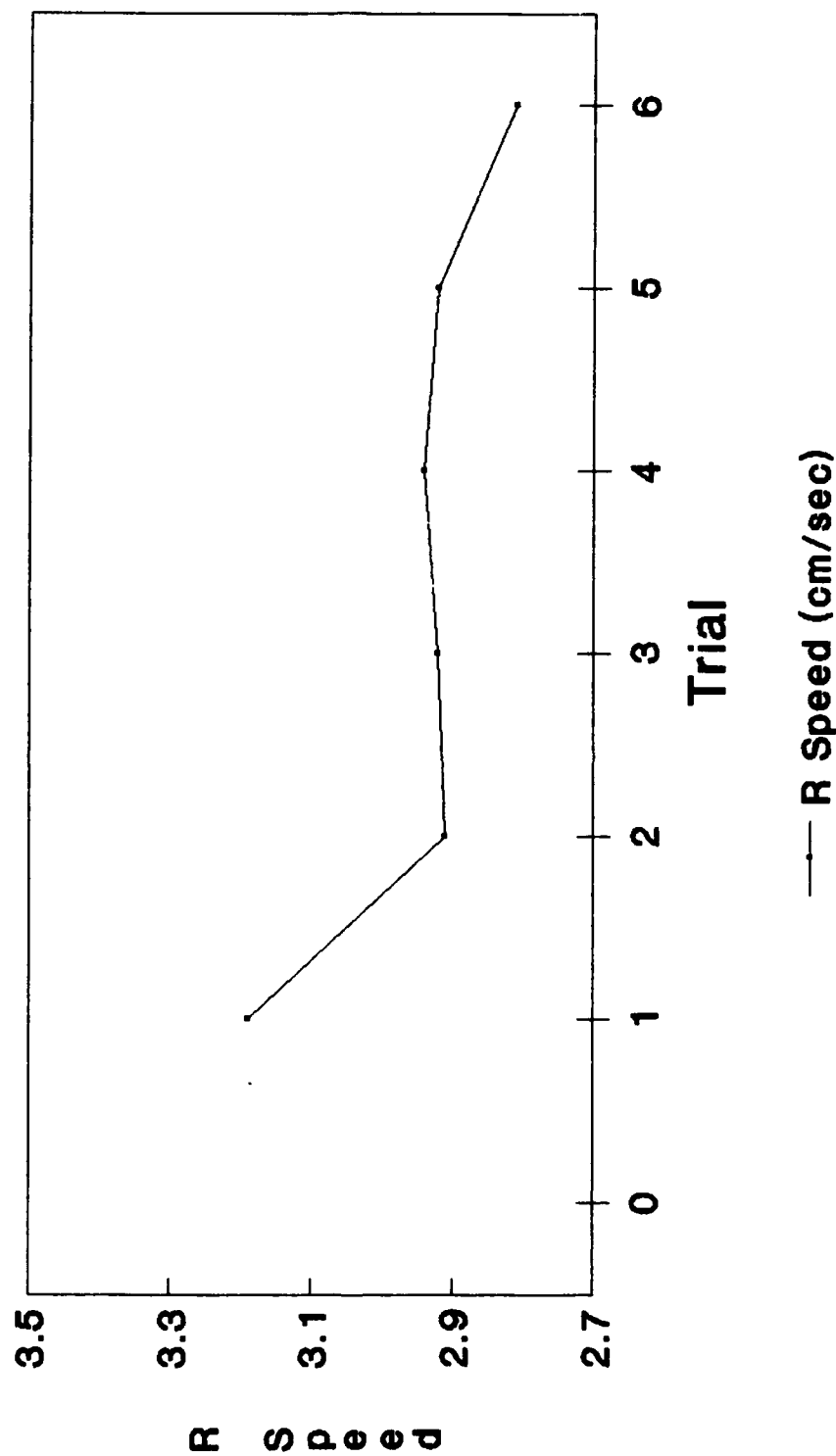


Figure 4