Treatment of the Inversion Ankle Sprain: Comparison of Different Modes of Compression and Cryotherapy

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Relatively few studies have been performed to examine the effectiveness of different methods of treatment for the inversion ankle sprain. In this study, restoration of function following a grade II inversion sprain was compared among 34 subjects who received one of three methods of treatment, each of which incorporated an Air-Stirrup brace. The methods included uniform compression provided by elastic tape, focal compression provided by a U-shaped device, and focal compression with simultaneous cryotherapy. Although the results failed to demonstrate statistical significance at the .05 level ($p = .055$), the two groups that received focal compression attained each of nine levels of function in fewer days than the group that received uniform compression. The results of this study indicate that focal compression appears beneficial, but increased frequency and duration of cryotherapy does not appear to enhance the rate of recovery following an inversion ankle sprain.

Key Words: ankle sprain, compression, cryotherapy

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The inversion ankle sprain is one of the most common injuries experienced by individuals who are physically active (4, 7, 14, 18, 51). The exact mechanism of injury may involve a complex interaction of various external forces and combinations of joint positions, which determine the exact nature of the ligament damage that results. The vast majority of ankle sprains are associated with some degree of inward motion of the sole of the foot and some degree of damage to the anterior talofibular ligament (14, 23, 25, 39, 47). Inadequate treatment and rehabilitation of the inversion ankle sprain may result in ligament laxity, decreased strength of dynamic stabilizers, and proprioceptive deficits (8, 20, 43, 51).

For many years, treatment for ankle sprains varied greatly and was a controversial topic (4, 14, 15, 46). In recent years, there has been increasing acceptance of functional management as the optimal method of treating all but the most severe ankle sprains (7, 14, 24, 51). Functional management emphasizes protected functional utilization of the injured ankle to the greatest extent permitted by the individual's symptoms. The use of ice, compression, and elevation has been widely accepted as standard treatment for pain and edema control, which facilitates early weightbearing activity (21, 24, 27, 43, 45). In addition to the psychological and economic benefits of rapid restoration of normal function, early functional utilization may enhance both the rate and quality of ligament healing (2, 11, 26, 48-50, 55).

The recovery rate for ankle function following an inversion sprain may be related to the effectiveness of edema control at the injury site (42). Numerous authors have reported the use of a U-shaped felt or foam rubber device beneath an elastic wrap or adhesive tape for applying focal compression to the soft tissues adjacent to the fibular malleolus (3, 6, 10, 29, 40, 44, 51, 52). Focal compression appears to facilitate translocation of edema away from the site of injury and toward proximal noncompressed tissues. Such an effect has at least two potentially important benefits: *1*) edema is prevented from accumulating in an area where it may mechanically interfere with normal ankle joint function (15, 53), and *2*) dispersal of the edema over a larger area that is proximal to the injury site may facilitate its resolution by the lymphatic system (28, 38).

The most significant variable affecting the rate of recovery from an inversion ankle sprain is obviously the severity of tissue damage resulting from the traumatic incident (23).

Therefore, a method for identifying potential subjects who have sustained injuries of a similar degree of severity is needed for comparison of different treatment methods. Unfortunately, there is no widely accepted and precise method for defining ankle sprain severity.

Various classification schemes for ankle sprain severity have generally included three categories (ie., mild, moderate, and severe; grades I, II, and III; or first, second, and third degree), but the criteria for classification within a given category have varied greatly among authors. Recommended criteria have included: *1*) apparent joint instability (12, 20), *2*) suspected ligament pathology (ie., stretch, partial tear, or rupture) (12, 32), *3*) functional capabilities (19, 21, 42), *4*) number of ligaments damaged (5, 16, 35), and *5*) clinical symptoms (ie., pain, edema, ecchymosis, etc.) (23, 36, 41, 47). Some authors have used the terms grade I, grade II, and grade III to define specific types or combinations of ligament pathology (16, 35), and some have used the adjectives mild, moderate, and severe to describe the overall tissue response and functional impairment resulting from an ankle sprain (19, 22, 23, 33). Others have used these two sets of categorical terms in a synonymous manner (ie., grade I: mild, grade II: moderate, and grade III: severe) (13, 15, 20, 24, 36, 41).

Recovery of function following an ankle sprain has often been defined in a rather subjective and imprecise manner by authors who have reported the results of various treatment methods (24). The amount of time between injury and return to work or physical activity has been used as a criterion for comparison of methods in several studies (9, 17, 42). Linde et al (30) devised a 50-point scoring system for assessment of recovery from ankle sprain that represents various levels of function, pain, swelling, and mobility. Their scoring system incorporated four levels of ankle function, which included: *1*) inability to stand on the injured extremity, *2*) unfit for work, *3*) unfit for sports, and *4*) no functional impairment. Hocutt et al (21) assessed the recovery of subjects who had sustained ankle sprains of similar severity by recording the number of days required to attain each of three levels of functional performance without pain. The three levels of recovery were defined by functional tasks of increasing difficulty, which included walking, climbing stairs, and running and jumping. Lysholm and Gillquist (31) have devised a 100-point scale that provides numerous criteria for quantifying various aspects of knee function following surgery. A score of 0 points represents complete functional disability, and a score of 100 points represents normal function.

The recovery rate for ankle function following an inversion sprain may be related to the effectiveness of edema control at the injury site.

The purpose of this study was to examine the effects of three different modes of application of cold and compression on the rate of recovery of ankle function following an inversion sprain. Selected elements from previously reported function recovery scales (21, 30, 31) were incorporated into a 100-point, 11-level function scale that was devised for this study. The null hypothesis was no difference in the average number of days required for injured subjects to attain any given level of function.

METHODS

Subject Selection

All cadets and military personnel who entered the Cadet Physical Therapy Clinic of the United States Air Force Academy for treatment of an inversion ankle sprain during a 6-month study period were considered potential subjects. To control for variation in sprain severity among subjects included in the study, subject selection was performed in two stages.

The first stage of subject selection involved the use of an ankle sprain severity scale, which consisted of six categories of criteria for each of three grades of severity (Table 1). Classification of sprain severity was made by one of the authors on the basis of a prospective subject's clinical signs and symptoms at approximately 24 hours postinjury. Only potential subjects whose injuries were classified as grade II (42 subjects) were retained in the study.

Because the degree and resulting duration of functional impairment from an inversion ankle sprain is impossible to predict accurately during the acute phase of injury, a grade II sprain was further defined as one that was characterized by the ability to walk with a normal, nonlimping gait in less than 7 days and the ability to perform a single-leg hop test on the injured extremity within 14 days, but not sooner than 4 days. Thus, the second stage of subject selection consisted of a retrospective review of each prospective subject's history of functional impairment. Those whose histories were inconsistent with the strict definition of a grade II sprain were excluded from the statistical analysis (eight subjects).

Among 34 subjects whose injuries met criteria for inclusion in the study were 28 males and six females, none of whom had sustained a sprain to the injured ankle within the previous 12 months. The subjects ranged in age from 18 to 28 years,

Criteria	Grade I	Grade II	Grade III
Evidence of instability	None	None or slight	Definite
Reaction to manual inversion stress	Mild to moderate discomfort	Moderate to intense discomfort	No pain or intense discomfort
Localization of tenderness	None over CFL Mild to moderate over: ATaFL or ATaFL + ATbFL	Moderate to intense over: ATaFL, ATaFL + ATbFL, ATaFL + CFL, or ATaFL + ATbFL + CFL	Intense over: ATaFL, ATaFL + ATbFL, ATaFL + CFL, or ATaFL + ATbFL + CFL
Suspected pathology	Stretch of ATaFL, and possibly ATbFL, without macroscopic disruption	Partial tear of ATaFL and possibly ATbFL and/or CFL	Complete tear of ATaFL and possibly complete or partial tear of ATbFL and/or CFL
Weight bearing capability	Full or partial without significant pain	Difficult or impossible without supportive device (ie., brace, tape, cane)	Impossible
Edema accumulation	Gradual onset Easily controlled	Sudden onset Possible to control and disperse to some extent	Sudden onset Difficult or impossible to control
	Slight ecchymosis	Significant ecchymosis	Large volume spread over broad area

ATaFL: Anterior talofibular ligament.
ATbFL: Anterior tibiofibular ligament.
CFL: Calcaneofibular ligament.

TABLE 1. *Criteria for classification of ankle sprain severity.*

and the mean age of the subjects was 20.35 years (sd = 1.81).

Procedures and Materials

Three different methods of sprain treatment were administered during the study period, which was divided into three successive phases. Only one method of treatment was administered during each phase. Thus, assignment of subjects to treatment groups was randomized in the sense that the treatment received by a given subject depended upon the date of injury, which was completely unpredictable.

The three treatment methods included: *1*) elastic tape (2-in Conform, Bike Athletic Co., Knoxville, TN) applied in a continuous heel lock configuration, followed by application of a standard Air-Stirrup brace (Aircast Inc., Summit, NJ) (Group I: AS + ET), *2*) application of a U-shaped/liquid-filled device (Aircast Cryo/Strap, Aircast Inc., Summit, NJ) that had been stored at normal room temperature, followed by application of a modified Air-Stirrup brace (Group II: AS + UN), and *3*) application of a U-shaped/liquid-filled device that was frozen at the time of application, followed by application of a modified Air-Stirrup brace (Group III: AS + UF). Group I and Group II consisted of 12 subjects each, and Group III consisted of 10 subjects.

The U-shaped Cryo/Strap device, which contains both water and nonfreezable liquid, was always applied over a cotton sock (Figures 1a, 1b, and 1c). The modified Air-Stirrup brace was identical to the standard Air-Stirrup brace, except that the lateral distal aircell was removed to accommodate the Cryo/Strap device (Figure 2). In all cases, the subject's shoe was applied over the Air-Stirrup brace (Figure 3). Subjects were instructed to wear the brace continuously during the day and throughout the night.

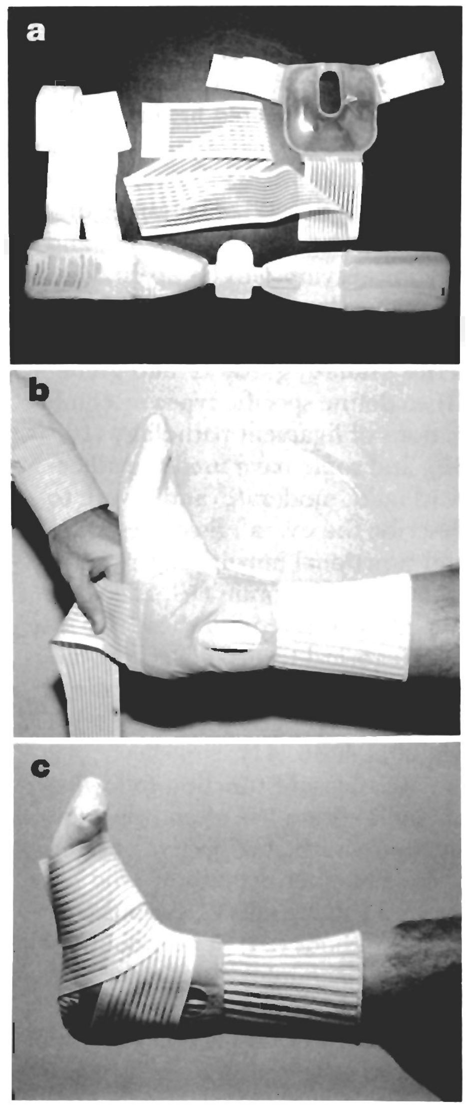

FIGURE 1. *a) U-shaped/liquid-filled Cryo/Strap device and modified Air-Stirrup brace. b) Application of Cryo/Strap to lateral aspect of ankle. c) Completed application of Cryo/Strap with elastic strap covering forefoot. (From Wilkerson (52) with permission).*

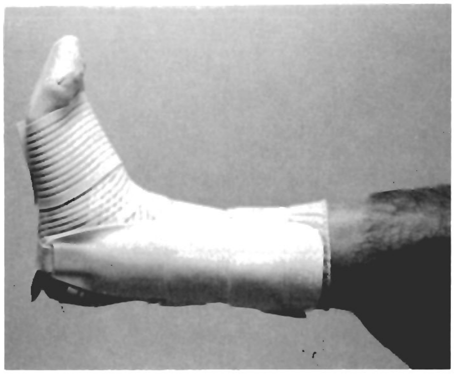

FIGURE 2. *Application of modified Air-Stirrup brace over Cryo/Strap (From Wilkerson (52) with permission).*

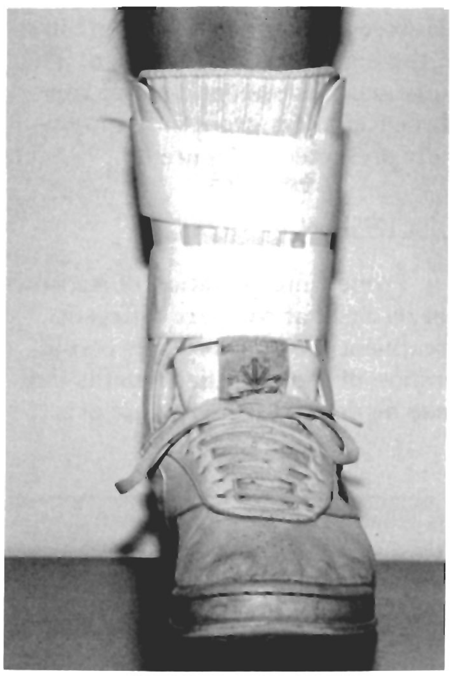

FIGURE 3. *Application of athletic shoe over brace. (From Wilkerson (52) with permission).*

All subjects received some form of cryotherapy at least one time per day during the acute phase of injury. Subjects in Group I and Group II received ice packs applied directly to the skin of the injured ankle for 20–30 minutes. Subjects in Group III were given a second Cryo/Strap device and were instructed to exchange a thawed device with a frozen one at 4-hour intervals throughout the day during the acute phase.

Assessment of Function

Ankle function was quantified by means of an 11-level, 100-point scale (Table 2). Each day postinjury, a subject was given a functional rating that represented the greatest level of function that the subject was able to demonstrate on that day. Complete functional disability was defined as primary reliance on a swing-through crutch gait for ambulation (PCR: 0). Continuous partial weightbearing (CPW: 10) was defined as continuous use of a walk-through crutch gait or reliance on a cane for ambulation. Continuous full weightbearing (CFW: 20) was achieved when a subject no longer depended on crutches or a cane for ambulation, and a normal walking gait (NWG: 30) was defined as the absence of a significant limp. The fifth level of function was achieved when a subject was able to jog straight ahead continuously for at least 400 m (SAJ: 40). A normal running gait (NRG: 50) was defined as the ability to run at ¾-speed for at least 100 m and without evidence of abnormal unilateral movements.

Functional impairment from an inversion ankle sprain is impossible to predict accurately during the acute phase of injury.

Limited multidirectional capability (LMC: 60) was defined as the ability to change the direction of body movement while bearing the body weight completely on the injured extremity. Limited multidirectional capability was determined by a single-leg hop test, which consisted of hopping on floor marks that were arranged in a zig-zag pattern. The length of the hopping course was 10 ft (3.048 m), and its width was 18 in (45.72 cm). Five diagonal hops were performed to the end of the course, a 180° hop-turn was performed, and five additional diagonal hops were performed as the subject returned to the starting point. To enhance the sensitivity of the test, it was performed without any form of ankle support (ie., no brace, tape, or shoe).

When a subject returned to limited participation in stressful functional activities, with some degree of activity modification or restrictions, a functional rating of 70 points was assigned (RFU: 70). Either an Air-Stirrup brace or tape was worn during all functional activities. Once a subject had advanced to unrestricted participation in physical activities, a distinction was made between a significant deficit in normal speed and agility (USD: 80) and a minor deficit in normal speed and agility (UMD: 90). The percentage of difference between the single-leg hop test times for the uninjured extremity and the

Points	Level of Function
0....	Primarily crutch-reliant (PCR)
10....	Continuous partial weightbearing (CPW)
20....	Continuous full weightbearing (CFW)
30....	Normal walking gait (NWG)
40....	Straight-ahead jogging (SAJ)
50....	Normal running gait (NRG)
60....	Limited multidirectional capability (LMC)
70....	Restricted functional utilization (RFU)
80....	Unrestricted activity, significant deficit (USD)
90....	Unrestricted activity, minor deficit (UMD)
100....	Full functional capability (FFC)

TABLE 2. *Postsprain function scale.*

injured extremity (unsupported) was used as the criterion for this distinction. A difference of 10% or less was considered a minor deficit (ie., 90–99% of normal functional capability).

Full functional capability (FFC: 100) was included as the eleventh level of the functional scale, but few subjects were available for continued evaluation after they had attained a high level of function. Therefore, data collection was terminated after a subject had attained a functional rating of 90 points.

Data Analysis

The dependent variable in the statistical analysis was the number of days required to attain each of nine levels of function (10 through 90). Periodic unavailability of 10 of the 34 subjects during the course of their recovery resulted in 22 missing values. Because a very strong linear relationship was evident between level of function and days required in every case (Pearson $r = .96–.99$), missing function scores were estimated by a regression equation that was calculated from the available data for each individual subject. The 22 estimated values were combined with 284 actual values, and the data were analyzed by a three (treatment methods) by nine (levels of function) repeated measures analysis of variance procedure for unequal group sizes described by Winer (54).

An alpha of .05 was selected for rejection of the null hypothesis. Because a very large treatment effect is necessary to demonstrate a statistically significant difference at the .05 level among small groups of subjects, an analysis of the power of the study design was performed to estimate the probability of a type II error (beta).

RESULTS

The results of the analysis of variance are presented in Table 3. The *F*-ratio calculated for evaluation of a significant difference among treatment methods corresponded to a *p*-value of .055. Thus, the null hypothesis was not rejected.

Source	SS	*df*	MS	*F*	*p*
Method (M)	248.03	2	124.02	3.18	.055
Subjects: M (S:M)	1208.20	31	38.97		
Function (F)	4772.89	8	596.61	98.45	>.001
MxF	64.77	16	4.05	0.66	.832
FxS:M	1528.49	248	6.16		

TABLE 3. *ANOVA summary table for days required to regain function.*

Calculation of the noncentrality parameter for the effect of treatment methods (phi) resulted in a value of 1.48, which corresponds to a beta value of approximately .42 (alpha = .05, $df = 2, 31$). As expected, the power of the study design to identify a true difference among methods at the .05 level of significance was found to be relatively low ($1 - \text{beta} = .58$).

Cell means and standard deviations are presented for each group at each level of function in Table 4. Despite the lack of a statistically significant difference among methods, a consistently slower rate of recovery of each level of function was observed for Group I. Differences between Group I and Groups II and III were also observed to be greatest at the higher levels of function. The functional assessment data for the three treatment groups are graphically presented in Figure 4.

Function Level	Group I (AS + ET)	Group II (AS + UN)	Group III (AS + UF)	Function Level Means
10	1.67	1.17	1.10	1.32
	(0.99)	(0.58)	(0.32)	
20	2.42	1.33	1.40	1.74
	(1.51)	(0.65)	(0.97)	
30	3.33	2.42	2.90	2.88
	(1.37)	(0.79)	(0.99)	
40	6.08	4.67	4.30	5.06
	(2.15)	(1.61)	(1.25)	
50	8.25	6.33	5.70	6.82
	(2.73)	(2.54)	(2.16)	
60	9.67	6.92	7.40	8.03
	(2.77)	(2.79)	(2.27)	
70	11.50	8.75	8.90	9.76
	(4.40)	(4.41)	(2.92)	
80	12.83	10.12	10.10	11.09
	(4.37)	(4.02)	(3.48)	
90	15.25	11.67	12.30	13.12
	(6.09)	(4.70)	(4.30)	
Group Means	7.89	5.94	6.01	

AS + ET: Air-Stirrup + elastic tape.
AS + UN: Air-Stirrup + U-device nonfrozen.
AS + UF: Air-Stirrup + U-device frozen.

TABLE 4. *Means and standard deviations for days required to regain function.*

DISCUSSION

Proper interpretation of statistical results that compare different treatment methods requires consideration of the potential benefits that may be derived from the use of a

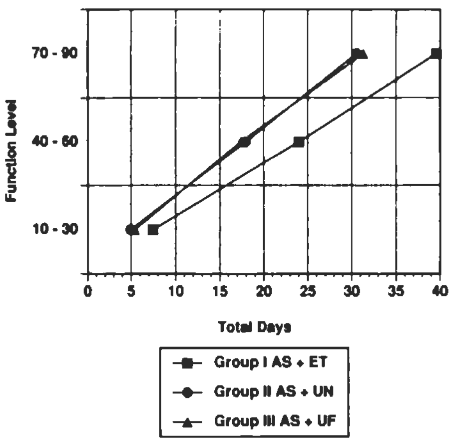

FIGURE 4. *Graphic presentation of grouped data for total days required to attain function levels. AS + ET: Air-Stirrup + elastic tape, AS + UN: Air-Stirrup + U-device nonfrozen, AS + UF: Air-Stirrup + U-device frozen.*

given method as well as consideration of potential risks that may be associated with its use. Although the *F*-test for difference among treatment methods failed to demonstrate a statistical difference at the .05 level of significance, the lack of availability of a larger number of subjects having comparable injuries greatly limited the power of this study.

Given the lack of any apparent negative side-effects for any of the methods, the relatively small number of subjects within each of the treatment groups, and the greater observed differences among the methods at high levels of function, the results of this study suggest that the mode of compression application may be an important factor that affects the rate of recovery of function following an inversion ankle sprain. Subjects who received focal compression to the soft tissues around the periphery of the fibular malleolus (Groups I and III) attained function levels 60 (LMC) through 90 (UMD) in approximately 25% fewer days than were required for subjects who received uniform compression (Group I).

The exact degree of cold and the duration of its application necessary for optimal therapeutic effect have not been established. Cryotherapy for treatment of ankle sprains typically consists of one or two daily sessions of cold application for 20–30 minutes (27, 34). Ankle surface temperature measurements beneath a frozen Cryo/Strap have been found to decrease to 16°C within 6 minutes of application, and they remained within the range of 12–16° C until 90 minutes postapplication (1). The closeness of the means for Group II (AS + UN) and Group III (AS + UF) across all levels of function suggests that the mode of application of external compression has a greater effect on the rate of restoration of function than does the frequency and duration of cryotherapy.

Temperature measurements beneath a frozen Cryo/Strap have been found to decrease to 16°C within 6 minutes.

The observed differences in the number of days required to attain high levels of ankle function was probably attributable to some factor beyond the voluntary control of subjects who were anxious to regain function rapidly. A possible explanation would be neural inhibition of dynamic stabilizers that results from edema accumulation within the ankle joint capsule. Increased intra-articular pressure has been shown to cause stretching of the joint capsule (37). Distortion of the capsule's normal configuration, which is closely adherent to underlying bones, may affect the function of mechanoreceptors within the capsule. Such an effect could be responsible for an injured subject's reluctance to attempt stressful functional activities. Decreased ability to maintain dynamic single-leg balance on an unstable platform may prove to be a quantifiable manifestation of an edema-related proprioceptive deficit.

CONCLUSIONS

On the basis of the findings of this study, the following conclusions may be drawn:

1) Subjects who receive focal compression to the soft tissues around the periphery of the fibular malleolus following an inversion ankle sprain appear to recover high levels of ankle function earlier than those who receive a more uniform mode of external compression.
2) Application of cold with greater frequency and longer duration than that which is typically administered in most clinical settings does not appear to increase the rate of recovery of ankle function following an inversion sprain. JOSPT

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