A COMPARISON STUDY OF 70% DIMETHYL SULFOXIDE AND 70% DIMETHYL SULFOXIDE WITH .05% FLUOCINONIDE AND STANDARD ANKLE TREATMENT AND THEIR EFFECTS ON EDEMA IN ANKLE SPRAINS

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The athletes who participated in this study also deserve my appreciation. It is my hope that this study will encourage more athletic trainers to do practical research in the field of sports medicine.

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CHAPTER I

INTRODUCTION

The ankle is one of the most commonly injured joints in athletics. It is well documented that injuries to the ankle are very common and occur frequently in athletics, constituting as much as 25% of all time-loss injuries in running and jumping sports.[1] In fact, it was also stated by Hamilton that the most common acute injury in the ballet dancer is the ankle sprain.[2] Also, in a study of 441,441 girls playing high school basketball by the National Athletic Trainers Association/National High School Injury Registry, 37,532 injuries to the ankle were projected, more than double the injury rate of all other body areas.[3] In general, numerous participation days are lost due to this injury and proper management is crucial to reduce the number of days lost.

High voltage galvanic muscle stimulation and cold whirlpool are considered in the sportsmedicine field to be the standard treatment to reduce the edema in ankle sprains. Dimethyl Sulfoxide (DMSO) is a drug used in the treatment of many athletic and nonathletic injuries. DMSO in previous studies has been shown to transport substances into the horny layer of skin. The rationale in using the Lidex (a cortisone solution) is that the DMSO may carry this into the horny layer and further reduce the edema than does the DMSO alone. Having been discovered at the turn of the century, DMSO is now in the limelight and is under scrutiny by various people to determine whether or not it has an effect on physical disorders.

Statement of the Problem

It was the problem of this study to compare the results from the effects of standard ankle treatment on the edema in ankle sprains with the results from the effects of 70% dimethyl sulfoxide and 70% dimethyl sulfoxide with .05% fluocinonide on ankle sprain edema.

Importance of the Study

This study provided information as to the effectiveness of dimethyl sulfoxide on ankle sprain edema. DMSO has been shown in previous studies to have some varying effect on edema, but by comparing these results with previously collected data, its further effectiveness may be determined. As a result, physicians and others in the sportsmedicine field may be able to make better decisions as to whether DMSO can become included in the realm of treatment procedures.

Hypotheses

The following were the hypotheses for this study:

Hypothesis 1. Standard ankle treatment will not be as effective as standard ankle treatment with 70% dimethyl sulfoxide combined with .05% fluocinonide on the reduction of edema in ankle sprains.

Hypothesis 2. Standard ankle treatment will not be as effective as standard ankle treatment with 70% dimethyl sulfoxide on the reduction of edema in ankle sprains.

Limitation

The limitation of the study was that the total number of ankles that were sprained during the period of August 11, 1988 and September 11, 1988 could not be predicted.

Delimitations

The delimitations of the study were:

1. The subjects were male college football players between the ages of 18 and 22 with sprained ankles.

2. Only edema was used as an indicator of the effectiveness of the two treatments.

3. High voltage galvanic muscle stimulation and cold whirlpool were the only two treatments used for the standard treatment protocol.

Definitions

The definitions for this study were as follows:

DMSO: Dimethyl Sulfoxide. (Patented as an industrial solvent, now an investigational new drug.) The chemical structure of DMSO is:

$$\begin{array}{c} CH3\text{-}S\text{-}CH3 \\ \| \\ O \end{array}$$

LIDEX. Lidex is the brand name of .05% fluocinonide made by Syntex, Inc., and is a form of cortisone.

High Voltage Galvanic Muscle Stimulation (HVGMS). HVGMS is a continuous, waveless, unidirectional current, chemical in action, which passes through the body and breaks up some of the molecules encountered in the component ion.[4]

Cold Whirlpool. Cold whirlpool is a form of cryotherapy combining hydrotherapy and cold water and ice at an average temperature of 45-55 degrees.

Ankle Volumeter With Obitrator. Ankle volumeter with obitrator is a commercially available device that measures the volume of ankles by submerging the area to be measured in water and weighing the amount of water displaced in grams.

Edema. Edema is an inflammation that occurs in the tissues after trauma to the area.

ENDNOTES

[1]Courson, R.; Cowling, J.; Anderson, A. "Evaluation of the injured ankle," Sportsmedicine Update, 3(2), Spring, 1988, pp. 1-4.

[2]Hamilton, W. G. "Sprained ankles in ballet dancers," Foot and Ankle, 3(2), September-October, 1982, pp. 99-102.

[3]Cramer First Aider, "The ankle: Basic injury care and prevention," January-February, 1988, pp. 1-4.

[4]Voight, M. L. "Reduction of post traumatic ankle edema with high voltage pulsed galvanic stimulation." Athletic Training, 19, Winter, 1984, pp. 278-279, 311.

CHAPTER II

REVIEW OF LITERATURE

The review of literature is divided into five categories: Anatomy, Ankle Injuries, DMSO, Standard Ankle Treatment, and the Summary.

Anatomy

The ankle joint is comprised of the distal ends of the tibia and fibula, which rests on the talus. The area which they fit into is called the mortice. The joint is a hinge, or ginglymus joint, and is quite structurally strong due to its bony and ligamentous arrangement.[1] The distal portions of the tibia and fibula are held together by the tibiofibular syndemosis, which is composed of the interosseous membrane, and the anterior and posterior tibiofibular ligaments.

The distal articular suface of the ankle joint is formed by the body of the talus, which has three articular surfaces: medial, lateral, and superior (or trochlear). The ankle joint is enclosed in a thin, articular capsule which is attached to the borders of the bone involved.[2]

The ligamentous structure of the ankle allows it to move around a single axis and provide structural support. On the lateral side of the ankle are three ligaments: the anterior talofibular, which originates from the neck of the talus and attaches to the tip of the fibula (the lateral malleolus); the calcaneofibular, which originates from the calcaneous and attaches to the fibula; and the posterior talofibular, which originates from the posterior process of the talus and attaches to the tip of the fibula. On the medial side, the ligamentous area consists of three fan-shaped ligaments referred to as the deltoid complex. These are the tibionavicular, posterior tibionavicular, and the tibiocalcaneal ligaments, which are named for their bony attachments.

The weakest aspect of the ankle is its muscularity. The long muscle tendons that cross on all sides of the ankle afford a maximum amount of leverage but a minimum amount of stabilization.[3] The muscles anteriorly are the extensor hallucus longus, extensor digitorium longus, and the anterior tibialis, which are involved in dorsiflexion of the foot and ankle. Medially are the posterior tibialis, flexor hallucis longus, and the flexor digitorium longus, which are involved with inversions of the ankle. Laterally are the peroneus brevis and peroneus longus, which are involved with eversions of the ankle. Posteriorly are the gastrocnemius and the soleus, which are involved with plantarflexion.

Ankle Sprains

The lateral ligamentous complex of the ankle is the most frequently injured in sprains, with approximately 85% of all ankle sprains involving the lateral ligaments.[4] The anterior talofibular ligament is the most commonly sprained ligament of the ankle joint.[5] The anterior talofibular has a high incidence of sprain since it is the first of the three lateral collateral ligaments to undergo stress when the ankle is inverted and plantarflexed.[6]

The classification of ankle sprains is based on degree of ligamentous damage; first, second or third degree. The following is from Thomas on the lateral ankle sprain classification:

> These structures are typically sprained in a running-cutting movement. That produces one of two abnormal motions: inversion with plantarflexion or, less often, pure inversion.

> Inversion with plantarflexion causes a progressive tearing of ligaments from anterior to posterior of the ligamentous structures. Thus, mild inversion-plantarflexion will only damage the anterior talofibular. A more severe inversion-plantarflexion injury will tear the anterior talofibular, which will cause the calcaneofibular ligament to withstand the stress and allow it to be torn. Finally, a severe inversion-plantarflexion sprain will tear the calcaneofibular ligament and therefore damage all three ligaments.7

Ankle sprains to the medial side constitute the remaining 15%. These isolated sprains of the deltoid ligament (tibionavicular, posterior tibotalar,and tibiocalaneal) are rare and slower to heal than those of the lateral side. When the foot turns outward, eversion is the most common mechanism of injury to these ligaments. The eversion injury frequently occurs when the foot is planted on the ground and another person falls against the lower leg.[8] As the lateral malleolus extends approximately one-half inch further distally than the medial malleolus, there is often a fracture of the distal fibula involved with this mechanism of injury.[9] Classification of the everson sprain is based on the ligament damage to the deltoid ligament complex, as with lateral ligament complex.

Accompanying an ankle sprain is edema, which most lay people will use to determine the extent of injury. When the anterior talofibular ligament is injured, fluid accumulates rapidly anterior and inferior to the fibular malleolus. The sinus tarsi, a concave space located between the talus and calcaneous, is commonly filled with fluid after ankle sprains. [10] As Wilkerson stated:

> Fluid collects rapidly in the tissue around the injury site following the traumatic incident, due to ruptured capillaries and arterioles, vascular dialation, increased blood flow, and increased permeability of the walls of the still intact capillaries and arterioles adjacent to the injury site. Under normal conditions, a slightly higher outside pressure balance allowing exudate to leak out. This exudate is normally rich in fibrogin, which is deposited in the intercellular spaces as fine, interlacing filaments in which red and white blood cells and platelets become tangled, with the end result being a 'wall like' deposition of insoluable proteins around the injury site.

> . . . this process has the negative effect of delaying recovery, since the wall of necrotic debris inhibits the absorption of exudate and the delivery of reparitive agents to the injury site by the circulating blood.[11]

Mobilization of accumulating fluid from the tissue spaces surrounding the injury site and into the lymphatic system is necessary for optimal healing to occur.[12]

Standard Ankle Treatment

Various treatment procedures have been used to reduce recovery type. The traditional therapeutic approach for the treatment of edema is cryotherapy combined with compression and elevation.[13] Adjunctive use of high voltage galvanic muscle stimulation may also help retard the flow of blood and serum proteins into the extracellular space. The use of HVGMS for the reduction of post-traumatic edema has been reported by many authors.[14] The combination of cold whirlpool and HVGMS further reduces the edema in ankle sprains. Furthermore, this standard treatment combined with either 70% DMSO with .05% fluocininide or 70% DMSO was the basis for a recent study.[15]

Controlling the edema is the key to recovery. It allows early mobilization of the ankle joint, which reduces recovery time by increasing tensile strength of damaged ligaments, maintaining muscle strength and joint proprioception, encouraging lymphatic drainage, and inhibiting development of range of motion restrictions.[16]

Research indicates that the effectiveness of HVGMS is in doubt. However, many respected clinicians claim success in reducing edema with HVGMS.[17] Also, a recent survey of 19 athletic trainers disclosed that HVGMS is frequently used at the intercollegiate level (100% of those surveyed). From the 19 athletic trainers surveyed, 82% reported using

HVGMS concurrently with some type of cold treatment.[18] Ralston also stated in his study that HVGMS is commonly used by athletic trainers and physical therapists in treating injuries which occurred in athletic competition.[19]

Voight reported that the supporters of HVGMS for the reduction of post-traumatic edema have two rationales on which to base their theory. First, stimulation over the traumatized area may create a repulsion effect on negatively charged plasma proteins. Therefore, the number of proteins leaving the capillaries may be minimized. Secondly, the HVGMS may cause a repulsion movement of the negatively charged plasma proteins and edematous material to another area, thereby decreasing the pooling and utilizing the already maximum venous-lymphatic system to a greater degree.[20]

Ralston also stated three guidelines that the researcher offers from a compilation of information from various sources. These are:

1. There is very little, if any, "state of the art" research published that gives definitive uses for high voltage galvanic muscle stimulation.

2. A protocol for the most effective use of HVGMS can, in fact, be synthesized from the knowledge possessed on the subject today.

3. Within the scope of the research done, these guidelines are believed to be the most effective methods for the use of HVGMS.[21]

Since the goal of early treatment is to delay or minimize the edema formation, the reduction of plasma proteins flowing through capillaries should be of prime concern. Clinically, it appears that HVGMS does produce a change in capillary fluid dynamics with resultant reduction in edema.[22] The reduction of ankle edema is a key process to both recovery and the start of rehabilitation.

DMSO

Dimethyl sulfoxide was first patented in the 1940's as an industrial solvent. In 1963, a physician, Stanley Jacob, introduced DMSO as a treatment for the swelling and pain of arthritis. Jacob also reported that DMSO penetrated the skin, aided the transportation of other drugs through the skin, decreased swelling, promoted healing, and had analgesic properties.[23] In 1972, the National Academy of Sciences stated that DMSO should remain an investigational drug, and in 1980, the Food and Drug Administration considered DMSO as an investigational new drug.

Sulzberger concluded from his experiment that since DMSO carried substances rapidly into the horny layer of the skin, it could be useful as a therapy vehicle for agents used on inflammatory conditions and superficial skin infections.[24]

The common side effect of DMSO is bad breath. This appears three to five minutes after application and produces a garlic smell, while the subject experiences the taste of raw oysters. Other side effects include: headache, nausea, skin irritations, generalized dermatitis, and an allergic reaction.

A recent study stated that, in the treatment of bursitis, 80% DMSO was effective in reducing inflammation, while 10% DMSO was only poor to fair in reducing inflammation. The results obtained with standard therapy were comparable to the results obtained with 80% DMSO.[25]

The National Athletic Trainers Association Drug Education Committee purports 99 injuries which might be worthy of further investigation using DMSO treatments. These injuries include: Achilles tendon strain, ankle sprain, ankle subluxation, and knee sprain[26] (see Appendix A).

DMSO and Lidex

With DMSO aiding in the transportation of other drugs through the skin, Lidex (fluocinonide, a cortisone solution) was added in Fair's (1987) study. The purpose of this was to have the DMSO transport the Lidex into the horny layer of the skin, thus further reducing the edema.

Summary

As stated, ankle injuries constitute 20-25% of all time-loss injuries.[27] The treatment of these injuries and the reduction of edema is one of the keys to reducing the time lost and returning the athlete to participation as soon as possible.

Various treatment procedures have been used to reduce recovery time. The traditional approach for the treatment of edema is cryotherapy, combined with compression and elevation.[28] The use of high voltage galvanic muscle stimulation for the reduction of post-traumatic edema has been reported by many authors.[29] Furthermore, this standard ankle treatment combined with either 70% dimethyl sulfoxide or 70% dimethyl sulfoxide with .05% fluocinonide was the basis for a recent study.[30]

ENDNOTES

[1]Courson, R.; Cowling, J.; and Anderson, A., "Evaluation of the injured ankle," Sportsmedicine Update, 3(2), Spring, 1988, pp. 1-4.

[2]Ibid.

[3]Ibid.

[4]Ibid.

[5]Wilkerson, G. B., "Treatment of ankle sprains with external compression and early mobilization," The Physician and Sportsmedicine, 13(6), June, 1985, pp. 83-90.

[6]Wilkerson, G. B., "The inversion ankle sprain: Reducing recovery time by controlling edema," unpublished paper, Centre College of Kentucky, Danville, Kentucky, n.d.

[7]Thomas, J., "Ankle sprains classification based on anatomical structures," Athletic Training, 21(3), Fall, 1986, pp. 254-257.

[8]Courson, R.; Cowling, J.; and Anderson, A., ibid.

[9]Ibid.

[10]Wilkerson, G. B., "Treatment of ankle sprains with external compression and early mobilization," ibid.

[11]Wilkerson, G. B., "The inversion ankle sprain: reducing recovery time by controlling edema," ibid.

[12]Wilkerson, G. B., "Treatment of ankle sprains with external compression and early mobilization," ibid.

[13]Voight, M. L., "Reduction of post traumatic ankle edema with high voltage pulsed galvanic stimulation," Athletic Training, 19, Winter, 1984, pp. 278-279, 311.

[14]Ralston, D. J., "High voltage galvanic stimulation," Athletic Training, 20, Winter, 1985, pp. 291-293.

[15]Fair, J. D., "The effect of dimethyl sulfoxide and dimethyl sulfoxide with fluocinonide on edema in sprained ankles," unpublished doctoral dissertation, Oklahoma State University, 1987.

[16]Wilkerson, G. B., "Treatment of ankle sprains with external compression and early mobilization," ibid.

[17]Brown, S., "Ankle edema and galvanic muscle stimulation," The Physician and Sportsmedicine, 9(11), November, 1981, p. 137.

[18]Ralston, D. J., ibid.

[19]Ibid.

[20]Voight, M. L., ibid.

[21]Ralston, D. J., ibid.

[22]Ibid.

[23]Fair, J., ibid.

[24]Ibid.

[25]Ibid.

[26]Ibid.

[27]Thomas, J., ibid.

[28]Voight, M. L., ibid.

[29]Ralston, D. J., ibid.

[30]Fair, J. D., ibid.

CHAPTER III

METHODS AND PROCEDURES

The purpose of this study was to test the hypothesis that there would be no significant difference between standard ankle treatment and 70% DMSO or 70% DMSO with .05% fluocinonide on edema in ankle sprains. The standard ankle treatment group was added to Fair's (1987) data using the identical protocol.

All members of the 1988 Oklahoma State University football team had their ankles measured in commercially made volumeters before the start of football practice in the Fall of 1988. The volume of water displaced by their ankles was weighed and recorded in grams. For injured athletes, the injured ankle was examined and evaluated as a first, second, or third degree sprain. Both ankles were measured in the volumeters and the information was recorded with the other measurements on the data sheet (see Appendix B). All measurements and treatments were done at the Oklahoma State University Athletic Training Facility.

Standard Treatment Group

The injured athletes received the standard ankle treatment of 15 minutes of cold whirlpool, 10 minutes of high voltage galvanic muscle stimulation, and another 10 minutes of cold whirlpool. The ankles were then wrapped with a four-inch elastic bandage from the ball of the foot to the base of the gastrocnemius. The athletes were released and instructed to report to the training room the next morning. Following a volumeter assessment, the athletes received the standard ankle treatment in the same manner as before. When the athletes returned for practice, the ankles were measured again. If the athletes were able to practice, the injured ankles were taped. If they could not practice, they remained in the training room for the duration of practice and received the standard ankle treatment. The athletes who practiced received a treatment after practice. This procedure continued for the designated time; that is, treatment three times a day for a week post-injury onset.

DMSO Treatment Group

The DMSO treatment group received the same treatments as the standard ankle treatment group. The only exception was that the DMSO group received an application of either 70% DMSO at injury onset, 24 hours, and 48 hours post-injury.

DMSO With Lidex Treatment Group

The DMSO with Lidex treatment group received the same treatments as the standard ankle treatment group. The only exception was that the DMSO with Lidex group received an application of 70% DMSO with .05% fluocinonide (Lidex) at injury onset, 24 hours, and 48 hours post-injury.

Analysis of Data

The data for volume was compiled and analyzed using a 3 x 4 repeated measures analysis of variance with a grouping factor at three levels (the three treatment groups) and a trial factor at four levels (pre-injury, initial injury, 48 hours post-injury, and 168 post-injury hours). The means were analyzed by the Newman-Keuls multiple range test. Volume difference was determined at the initial injury, 48 hours, and at 168 hours post-injury by subtracting the pre-test measurement to give a difference in weight in grams.

The data for volume difference were compiled and analyzed using a 3 x 3 repeated measures analysis of variance with a grouping at three levels (the three treatment groups) and a trial factor at three levels (initial injury, 48 hours, and 168 hours). The means were then analyzed by the Newman-Keuls multiple range test.

Summary

To compare the standard ankle treatment with the DMSO and DMSO with Lidex, commercially available foot and ankle volumeters were used to pre- and post-test ankle volume to measure changes in the amount of edema in the injured ankle. By accurately measuring the volume of the ankles before an injury occurred, the investigator established a pre-test measurement for the injured ankle. For the purposes of this study, the effectiveness of the standard ankle treatment and the DMSO and DMSO with Lidex treatments were based on the amount of edema reduced over the one-week testing period, as measured by changes in the volume of the ankles.[1]

ENDNOTES

[1]Fair, J. D., "The effect of dimethyl sulfoxide and dimethyl sulfoxide with fluocinonide on edema in sprained ankles," unpublished doctoral dissertation, Oklahoma State University, 1987.

CHAPTER IV

RESULTS AND DISCUSSION

The purpose of this study was to test the hypothesis that over the 168 hour testing period (1) there would be no difference in the effect of standard ankle treatment and standard ankle treatment with 70% DMSO combined with .05% fluocinonide on the reduction of edema in ankle sprains, and (2) there would be no difference in the effect of standard ankle treatment with 70% DMSO on the reduction of edema in ankle sprains. All 1988 Oklahoma State University football players' ankles were premeasured using commercially available volumeters. Those players who sustained ankle sprains participated in the study. Seven became subjects who received standard ankle treatments. From the Fair (1987) study, seven subjects received DMSO and seven received DMSO with .05% fluocinonide. A total of 12 measurements were taken after the injury on both ankles of the subjects over a seven-day period. Volume was examined over four testing times: pre-test, initial injury measurement, 48 hours post-injury, and at 168 hours post-injury. Volume difference was determined at the initial injury, at 48 hours post-injury, and at 168 hours post-injury by subtracting the pre-test measurement to give a difference in weight or edema in grams.

Analysis for Volume

The table of means for volume of the three treatment groups: DMSO, DMSO with Lidex (fluocinonide), and the standard ankle treatment group is shown in Table I. The repeated measures analysis of variance results are shown in Table II.

TABLE I

MEANS FOR VOLUME OF THREE TREATMENT GROUPS IN GRAMS (n = 7)

	DMSO	DMSO & Lidex	Standard	Average Means
Volume Pre. Inj.	1607.0	1515.4	1534.2	1552.2
Volume Inj.	1644.0	1531.1	1562.8	1579.3
Volume 48 Hrs.	1705.0	1560.1	1591.0	1618.8
Volume 168 Hrs.	1643.2	1552.4	1574.1	1589.9
Volume Mean/Grp.	1649.9	1539.7	1565.5	1585.0

The repeated measures analysis of variance indicated that there were no statistically significant differences among groups. It was also shown that there was no interaction effect among the groups. All of the treatments were equally effective at each point in time. However, the main effect of time was significant. The Newman-Keuls multiple range test indicated that there was an increase in volume between the pre-injury and initial injury measurements among groups. The Newman-Keuls also indicated that there was an increase in volume between the injury and the 48-hour post-injury measurement. There was a decrease in volume among all three groups between the 48-hour post-injury measurement and the 168-hour post-injury measurement.

TABLE II

ANALYSIS OF VARIANCE FOR VOLUME FOR THE THREE TREATMENT GROUPS

Source	SS	df	MS	f
Group	185849.8	2	92924.9	1.02
Error	163399.4	18	90744.4	
Time	47801.2	3	15933.7	12.73*
Time x Group	7854.7	16	1309.1	1.05
Error	67572.0	54	1251.3	

*Significant at the .01 level.

Figure 1 shows volume in grams of the DMSO, DMSO and Lidex, and standard treatments over time; at the pre-injury, initial injury, 48 hours post-injury, and 168 hours post-injury. The mean of the three groups is also shown in Figure 1 ("M"). Although not statistically significant, the DMSO group appeared to have a greater increase in volume between the injury measurement and the 48-hour post-injury measurement than did the DMSO and Lidex and the standard treatment groups. The DMSO and Lidex and standard treatment groups showed a similar parallel line in the results of the volume over time. This indicated that the volume means of the two groups, DMSO and Lidex and standard, had means in the pre-measurements with a difference of 19 grams. At the 168-hour post-injury measurements, the means of the volumes of the DMSO and Lidex and standard groups had a difference of 26 grams. This indicated that over a 168-hour period, there was no substantial difference between the two groups in volume.

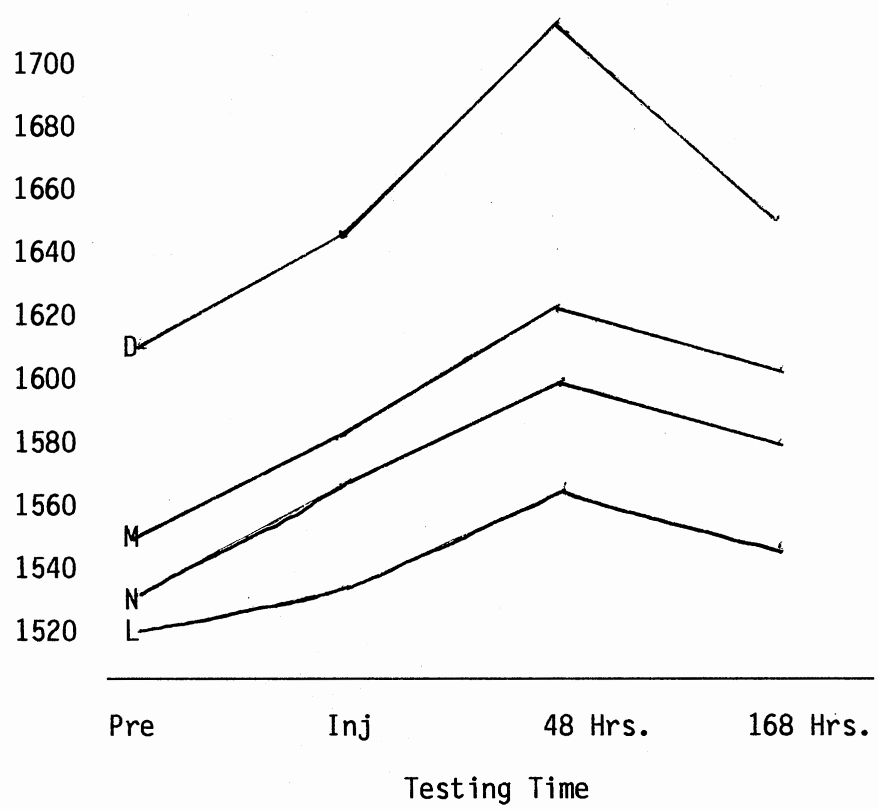

Figure 1. Volume in Grams of DMSO, DMSO and Lidex, Standard, and Mean Treatments Over Time (at Pre-Injury, Initial Injury, 48 Hours Post-Injury, and 168 Hours Post-Injury)

Analysis for Volume Difference

The table of means for volume difference of the three treatment groups of DMSO, DMSO with fluocinonide (Lidex), and standard treatment group is shown in Table III. The repeated measures analysis of variance results are shown in Table IV.

TABLE III

MEANS FOR VOLUME DIFFERENCE (VD) OF THE THREE TREATMENT GROUPS IN GRAMS

	DMSO	DMSO & Lidex	Standard	VD Mean
VD Inj.	37.0	11.8	28.5	25.8
VD 48 Hrs.	98.4	43.1	56.7	66.0
VD 168 Hrs.	36.2	35.4	39.8	37.1
VD Mean/Grp.	57.2	30.1	41.7	43.0

The volume difference measurements of the three groups showed that there was a significant difference over time; that is, from injury to 48 hours post-injury, the volume difference increased. Also, from the 48-hour post-injury measurement to the 168-hour post-injury measurement, the volume difference decreased for all three groups.

The Newman-Keuls multiple range test was used to analyze the treatment groups. There were no statistical differences when the groups were analyzed among themselves. However, the analysis of variance indicated that there was a statistical significance over time for the three groups.

TABLE IV

ANALYSIS OF VARIANCE FOR VOLUME DIFFERENCE
FOR THREE TREATMENT GROUPS

Source	SS	df	MS	f
Group	7763.2	2	3881.6	0.86
Error	81188.6	18	4510.4	
Time	18115.6	2	9057.8	6.91*
Time x Group	6228.4	4	1557.1	1.19
Error	47187.9	36	1310.7	

*Statistically significant at the .01 level.

The three treatment groups had a volume difference at 168 hours post-injury, similar to the volume difference at injury. This indicated that all three treatments were similarly successful in reducing the edema in ankle sprains.

Figure 2 shows the volume difference in grams over time of the three treatment groups and the mean of the three groups ("M"). This also indicated that the DMSO treatment group appeared to have a greater volume difference between the injury measurement and the measurement of 48 hours post-injury. Also, the volume differences of the DMSO and Lidex and standard groups were similar to each other. At the 168-hour post-injury measurement, the mean volume differences of all three groups were similar (36.28, DMSO; 35.42, DMSO and Lidex; and 39.85, standard group).

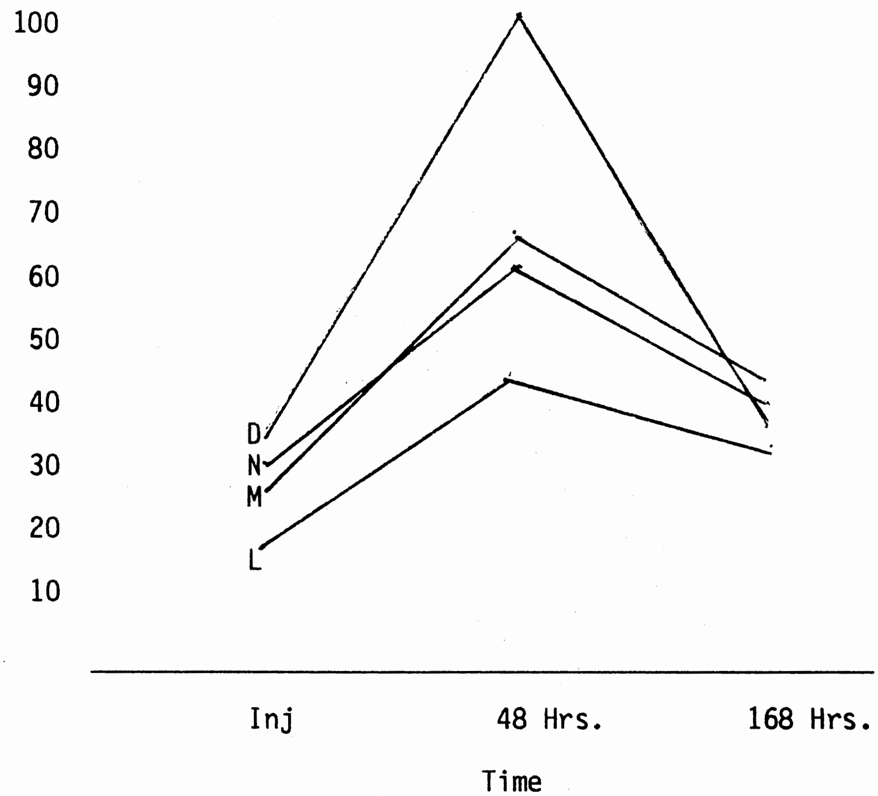

Figure 2. Volume Difference and Mean in Grams Over Time of the Three Treatment Groups

Discussion

In the previous study, it was demonstrated that DMSO and DMSO with fluocinonide had significantly similar effects on edema in ankle sprains over the 168 hour period.[1] However, with the three treatment groups in this study (DMSO, DMSO and Lidex, standard), it was shown that all three similarly affected the edema. It was also stated in the previous study that the DMSO with fluocinonide appeared to have been carried into the tissues and reduced the edema faster than did the DMSO alone.[2] The normal standard ankle treatment had the same effects as the DMSO with fluocinonide and also appeared to reduce the edema more than the DMSO alone.

The normal standard ankle treatment also appeared to control the edema more in the first 48 hours post-injury onset than the DMSO. The normal group was similar to the DMSO, with fluocinonide in controlling the edema in the first 48 hours.

It was also reported in the previous study that the side effects of DMSO alone was more than when the DMSO with fluocinonide was used.[3] There were no side effects reported with the normal standard ankle treatment group.

In choosing a treatment for ankle sprains, the physician must consider the side effects of the treatments and the overall effectiveness of them. With these factors, a better decision on the treatment protocol can be made.

ENDNOTES

[1]Fair, J. D. "The effect of dimethyl sulfoxide and dimethyl sulfoxide with fluocinonide on edema in sprained ankles," unpublished doctoral dissertation, Oklahoma State University, 1987.

[2]Ibid.

[3]Ibid.

CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This research was designed to test effects of the standard ankle treatment on ankle sprain edema compared to the results of 70% DMSO and 70% DMSO with .05% fluocinonide and their results on the edema in ankle sprains. The subjects were the 1988 Oklahoma State University football team members who sustained sprained ankles. Those participating in the study had their ankles measured in commercially available volumeters and the amount of water displaced weighed in grams. The results of the seven players who received the standard ankle treatment of cold whirlpool and HVGMS were compared to the results of the seven players who received standard ankle treatment combined with 70% DMSO and those seven players who received the standard ankle treatment combined with 70% DMSO combined with .05% fluocinonide. Four measurement times were used at all three treatment groups: pre-injury, initial injury onset, 48 hours post-injury onset, and 168 hours post-injury onset. The volume means and volume differences for the three groups were analyzed using a repeated measures analysis of variance and the Newman-Keuls multiple range test.

Findings

On the basis of this study, the following findings are presented:

1. The three treatments were equally effective for volume means on controlling the edema in ankle sprains.

2. The three treatments were equally effective for volume difference means on controlling the edema in ankle sprains.

Conclusions

On the basis of this study, the following conclusions were drawn:

1. The three treatment groups were equally effective in reducing edema in ankle sprains.

2. Since the three treatment groups had similar 168 hour measurements, physicians should consider which treatment would be more effective on edema in any given situation.

3. Physicians choosing DMSO with .05% fluocinonide should be aware that the DMSO with fluocinonide appears to control the volume and volume differences more effectively than the DMSO alone.

Recommendations

The following recommendations for future research are presented as a result of this study:

1. There should be another study done with an increase in the number of subjects.

2. Further research should be conducted using the DMSO with fluocinonide (lidex) and a control group (normal), since the results from these two groups are similar.

3. Different strengths of DMSO and fluocinonide should be varied, along with treatment and treatment times, to find the optimal amounts to best effectively control the edema in ankle sprains.

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APPENDIXES

APPENDIX A

NATIONAL ATHLETIC TRAINERS ASSOCIATION'S LIST OF 99 INJURIES OR CONDITIONS THAT MAY BENEFIT FROM DMSO TREATMENT

1. Abrasions
2. Abscesses
3. Achilles Tendon Strain
4. Achilles Tendon Tenosynovitis
5. Achillobursitis
6. Acne
7. Acromioclavicular Sprains
8. Adductor Longus Strains
9. Adductor Magnus Strains
10. Ankle Dislocation
11. Ankle Exostoses
12. Ankle Sprain
13. Ankle Subluxation
14. Anterior Tibial Compartment Syndrome
15. Anterior Tibial Tenosynovitis
16. Arch Strain
17. Arthritis
18. Baseball Finger-interphalangeal contusions
19. Bicipital Tenosynovitis
20. Blisters
21. Brachial Pleus Traction Injury
22. Bunion
23. Burns
24. Bursitis
25. Calcaneocuboid Ligament Strain
26. Carbuncle
27. Carpometacarpal Dislocation
28. Carpometacarpal Subluxation
29. Cellulitis
30. Contusions
31. Coccygodynia
32. Costochondral Sprain
33. Costochondral Strain
34. Contact Dermatitis
35. Seborrheic Dermatitis
36. Hematoma Aurus
37. Elbow Dislocation
38. Elbow Subluxation
39. Epicondylitis
40. Epidermatophytosis
41. Extensor Digitorum Longus Tenosynovitis
42. Extensor Hallucis Longus Tenosynovitis
43. Fat Pad Contusion
44. Felon
45. Fibular Collateral Ligament Bursitis
46. Finger Dislocation
47. Frostbite
48. Furunculosis
49. Gastrocnemius Strain

50. Glenohumeral Dislocation
51. Glenohumeral Subluxation
52. Gluteus Medius Strain
53. Gracilis Strain
54. Granuloma
55. Hamstring Strain
56. Hamstring Tenosynovitis
57. Heat Rash
58. Hemorrhoids
59. Herpes Simplex
60. Hip Dislocation
61. Hip Sprain
62. Hip Strain
63. Hives
64. Hiopectineal Bursitis
65. Hiopsoas Strain
66. Impetigo
67. Infrapatellar Bursitis
68. Ischiogluteal Bursitis
69. Knee Contusion
70. Knee Dislocation
71. Knee Sprain
72. Larynx Injury (Contusion)
73. Lumbosacral Sprain
74. Lumbosaeral Strain
75. Lunate Dislocation
76. Metacarpalphalangeal Dislocation
77. Myositis Ossificans
78. Nail, Subungual Hematoma
79. Nail, Ingrown
80. Nerve Contusion
81. Neuritis
82. Osgood-Schlatter's Syndrome
83. Osteochondritis
84. Osteochondritis Desicans
85. Patellar Dislocation
86. Patellar Tendon Strain
87. Periostitis
88. Peroneal Nerve Contusion
89. Peroneal Tenosynovitis
90. Plantar Wart
91. Plantaris Strain
92. Tenosynovitis
93. Muscle Strains
94. Sprains
95. Insect Bites
96. Stye
97. Tarsal Tunnel Syndrome
98. Carpal Tunnel Syndrome
99. Tendonitis

APPENDIX B

ANKLE INJURY RECORD

ANKLE INJURY RECORD

NAME ______________________ SPORT ______________________

INJURY DEGREE ______ (1,2,3)

INJURY: YEAR ______ MONTH ______ DAY ______ TIME ______

RIGHT ______ LEFT ______

HOUR	DATE	WHEN	P/T**	RIGHT	LEFT	BY	COMMENTS
				READINGS			
Pre-Test							
Injury							
12		morn					
20		pre					
24		post					
36		morn					
44		pre					
48		post					
60		morn					
68		pre					
72		post					
84		morn					
168		morn					(1 week post injury)

** P = Practice T = Treatment Only

VITA

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Master of Science

Thesis: A COMPARISON STUDY OF 70% DIMETHYL SULFOXIDE AND 70% DIMETHYL SULFOXIDE WITH .05% FLUOCINONIDE AND STANDARD ANKLE TREATMENT AND THEIR EFFECTS ON EDEMA IN ANKLE SPRAINS

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