A COMPARISON OF THE HEAT RETAINING CAPABILITIES OF ELASTO-GEL™ VERSUS SILICA GEL

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ABSTRACT

This study compared the heat retaining capabilities of Elasto-Gel, a new product, with that of the silicate gel found in traditional hot packs. Sixteen females were used as subjects. Thermister leads were attached to the anterior portion of each thigh to record the temperature of both packs during testing. The temperature changes were monitored and recorded every 30 seconds for the first five minutes and every minute thereafter for 30 minutes. Statistically, the results of the Tukey Honestly Significant Difference post hoc test (HSD) showed the temperature of the Elasto-Gel product was higher from minutes 0-4 than the silicate gel product. An analysis of variance test performed on the type of pack and their measured temperatures from minute 0 to minute 30 also showed no significant difference between packs. We concluded that there is no statistically significant difference in the two products as far as heat retention capabilities are concerned.

INTRODUCTION

Fire was one of man's first productions and since that time heat has been used for everything from cooking to healing. Ancient Hindu and Greek physicians alike understood the benefits of boiling water to purify wounds. The application of heat has since branched into more than twenty types of artificial therapeutic heat; including conductive heat, convective heat, electrical heat, luminous heat, and infrared. Nonetheless, the most popular form of artificial heat used by therapists today remains the traditional hot pack.

As a part of physical rehabilitation, hot packs not only provide the relaxation to tense muscles, but also provide pain relief, decreased joint stiffness, and increased local blood. Although hot packs are generally superficial heaters, they also have an effect on deeper structures through reflex mechanism. As superficial heaters, however, hot packs are most beneficial to areas of the body that contain little soft tissue padding such as the hands, knees and feet. These structures have always been challenging to treat with hot packs because of their uneven surface areas.

While therapists have had to make choices between which brand of ultrasound or fluidotherapy unit to use, few types of hot packs have been available for clinical use. One different type of pack is the Kenny pack, a steam heated wool cloth that is hand wrung and applied rapidly while the temperature is 140F. Because the heat rapidly dissipates, this pack is best used for short-term stimulation. Another type of hot pack is the common rubber hot water bottle. Still another is the electrical heating pad which can be used with or without a wet cloth. Caution should be taken with these pads as electric shock is a possibility when combining the wet cloth with an electrically heated unit. Clinically, however, the most common type of hot pack is the hydrocollator pack. Hydrocollator packs are filled with a hydrophilic silicate gel, covered with a canvas case, and stored in a hydrocollator unit that is filled with water that ranges in temperature from 71.1C to 79.4C (160.0 F - 175 F). The towel layers required for a traditional hot pack treatment range from six to eight layers depending on patient tolerance and towel thickness. Between treatments the packs are stored in the heating unit and checked periodically for leakage. Silica gel packs are usually discarded if leakage is found.

Recently, a company has challenged the tradition and produced a product that competes with the canvas covered silica gel pack. The product is called Elasto-Gel and is manufactured by Southwest Technologies, Inc. This gel is also hydrophilic and is, therefore, protected in a plastic cover and then covered with a breathable stretch cloth material that is removable. The product's characteristics include versatility and conformity. The product can be used as a hot pack or a cold pack. It can be heated in a microwave, a conventional oven, or in a hydrocollator if sealed in a waterproof container. It can also be stored in a freezer and will remain flexible even at -20F. The company makes different square sizes as well as ankle wraps and elbow sleeves that are made to fit like a second skin. The product is designed to be used in conjunction with a Velcro™ strap that applies pressure, as well as, a hot or cold treatment.

Because heat retention is a crucial aspect of the effectiveness of heat treatments, this study was done to compare the heat retaining capabilities of the Elasto-Gel product with the capabilities of the traditional silica gel product.

METHODS

Subjects

Subjects were 16 females between the ages of 21 and 36. Subjects were recruited on a voluntary basis and were required to have no known adverse reactions to heat, no known peripheral vascular disease, and generally good health. A written consent form was obtained from all subjects prior to testing.

Experimental Design

Prior to subject testing, both the Elasto-Gel and Silica gel hot packs were placed in a standard hydrocollator heating unit. The Elasto-Gel pack was placed in two sealed plastic freezer bags before it was placed in the hydrocollator to ensure that the product, which is hydrophilic, would not get wet. Both packs were allowed to heat at least one hour before they were used in testing procedures. A temperature reading of the hydrocollator unit was taken approximately ten minutes prior to testing as was a room temperature reading, to ensure that both packs began the testing at identical temperatures internally and environmentally.

Subjects were asked to wear clothing that exposed their upper quadricep regions. All subjects were given a cursory review of the testing procedure and had a skin calliper test taken on both right and left thighs. Subjects were then asked to long-sit or recline on a plinth where thermister leads were attached to the mid-anterior portion of both thighs. Pillows were used under both knees and behind the back for patient comfort. An initial skin temperature was taken prior to heat application, then the thermister leads were turned around to record pack temperatures. Both packs were simultaneously taken out of the hydrocollator and placed onto the subject's thigh with the appropriate clinical use of toweling for each type of pack, one towel with the Elasto-Gel pack and six to eight towels with the Silica gel pack. The Elasto-Gel pack was placed on the subject's left thigh while the Silica gel pack was placed on the subject's right thigh. an initial temperature reading was taken from each pack. Both packs were then secured to each leg by a velcro strap. A thirty second reading was then taken and recorded for each pack. Temperature readings were then recorded every thirty seconds for the first five minutes and every minute thereafter for a total of thirty minutes. Subjects were asked to report any feeling of uncomfortableness or dizziness at any time during testing. After thirty minutes, the subjects were asked to remain seated while the packs, towels, and thermister leads were removed. The skin was then examined for any adverse reactions to heat and observations were recorded.

Each testing procedure required approximately 45-50 minutes of each subject's time. No follow-up time was necessary.

ANALYTICAL METHODS

A standardized data sheet including subject's name, age, subject number, the date and time of the testing, room temperature, hydrocollator temperature, pre-test skin temperatures, and calliper skinfold measurements for bilateral quadricep areas, and the temperature readings of both type of packs were collected for each subject. These data sheet results were entered into a Wordstar word processing program which then was entered for an Analysis of Variance test. In comparing the type of pack with time of application, we failed to reject the Null Hypothesis (p less than .01), yet in the comparison of pack temperature with the time of the pack application, the Null Hypothesis was rejected (p greater than .01).

A cross-breakdown of the data sheet results gave the mean temperature per minute, the number of subjects used in obtaining the mean, and the standard deviation of the mean for each type of pack. These results were printed in Table 1. The mean temperatures were graphed against the time of application in Figures 1 and 2.

The Tukey honestly Significant Difference post hoc test (= .01) measured the interaction of the type of pack with time. With HSD = 1.612, we rejected the Null Hypothesis for minutes 0, 1, 2, 3, and 4.

RESULTS

Figure 1 illustrates the mean Farenheit temperatures per minute of Elasto-Gel and Silica gel averaged over the sixteen subjects. Both curves exhibit a similar shape from minutes 4.5 to 30, with the greatest variations in shape occurring between minutes 0 and 4.5, as shown by Figure 2. Elasto-Gel has a 4% increase in temperature over that of Silica gel at time 0, 9% at time 1, 5% at time 2, 3% at time 3, and less than .5% increase at time 4.

Table 1 compares the mean Farenheit temperatures and standard deviations per minute of each pack. The peak mean temperature of Elasto-Gel is reached at minute 9 at 109.11 degrees (F.), with a standard deviation (SD) of 1.43. Silica gel reaches its peak at minute 8 at 109.88 (F.) with a SD of 1.50. This represents only a .7% difference in peak mean temperatures between the packs, with both packs reaching their peak by minute 9. The decline in mean temperature from minutes 9 to 30 is 3.4% for Elasto-Gel and 4.0% for Silica gel.

The greatest discrepancy in the pack temperature per subject occurred at minute 2 for Elasto-Gel, at which time the SD is 3.49, and at minute 1 for Silica gel with a SD of 2.09. At the mean peak temperature, which occurs for both packs at minute 9, the standard deviations are 1.43 for Elasto-Gel and 1.44 for Silica gel. The standard deviations then remain comparable for each pack per minute to minute 30, at which time the SD values are 1.16 and 1.13, respectively.

An analysis of variance test performed on the type of pack and its measured temperature at five-minute intervals from minutes 0 to 30 showed no significant difference between the packs, as illustrated by Table 2. A significant interaction, however, was found between the type of pack and the length of application the results of the Tukey Honestly Significant Difference post hoc test (HSD) showed the Elasto-Gel product was significantly higher in temperature for minutes 0, 1, 2, 3, and 4 than those of the Silica gel.

DISCUSSION

The method of heating the packs to be compared in this study was by immersion in a hydrocollator. This method ensured the same beginning temperatures of the two products. Due to Elasto-Gel's hydrophilic nature, this product was immersed within a zip-locked plastic bag in order to keep the product dry.

Hot packs transfer their thermal energy to the body by conduction. The hot pack is at a much higher temperature than the skin surface to which it is applied. Thermal energy is lost from the hot pack and gained by the tissues. According to Michlovitz (1986), the quality of heat gained and the subsequent physiologic responses to the heat gain are dependent on a.) the thermal conductivity of tissues, b.) the body volume exposed, and c.) the time of exposure. In this study, each type of hot pack was placed simultaneously on the subject's mid-quadriceps area for a total of 30 minutes, with each pack measuring 9" x 9", thus assuring an equal area for heat transfer. We have thus attempted to eliminate or minimize the above factors that have an influence on the amount of energy transferred.

The occurrence and magnitude of physiologic changes as a result of temperature elevation of body tissues are due to a number of factors. Michlovitz (1986) finds of great importance: a.) the extent of the temperature rise, b.) the rate at which energy is being added to the tissue, and c.) the volume of tissue exposed. Our study measured the temperature rise of each pack at the skin-pack at the skin-pack interface. This represents the transfer of heat from the pack and through the corresponding layer(s) of towel(s) to the skin surface. This temperature also correlates to any temperature elevation of body tissues, our data revealed mean peak temperatures to have a difference of .7% between the tow packs. This we find to be statistically not significant. Thus, we find no difference in the extent of the temperature rise.

The results of the HSD test showed there was a difference in the temperatures of the two types of packs for minutes 0 through 4. The increased standard deviations for minutes 0 through 8 also suggest a greater variability in the initial heating of the subjects and heat transfer from the packs. The clinical use of the Silica gel hot pack includes several layers of toweling, depending upon the individual towel thickness; the storage temperature of the pack; and patient tolerance. Since the method of transfer from hot pack to skin is by conduction, there is a direct exchange of heat from the moist core of Silica gel through the towel layers and to the skin. The physical thickness of layers between the hot pack and skin accounts for a lower initial temperature at time 0 compared to that of Elasto-Gel. Not until minute 4.5 does the temperature of Silica gel reach that of Elasto-Gel. On the other hand, the Elasto-Gel product is used with one layer of towel, due to the fact that the pack is immersed within a sealed plastic bag for the hydrocollator heating method, thus the product is not wet with clinical use. The heat transfer is also by conduction, yet from the pack through only one layer of toweling and onto the skin. This decrease in physical distance from pack to skin could account for the higher temperatures of the skin-to-pack interface for the first 4.5 minutes of application.

There are two points that we find to be of great importance in the comparison of heat retention of the two packs and its relevance to the heat transfer to body tissues. The first point concerns the rate at which energy is added to the tissue, which is in fact, the energy that has reached the skin-pack interface. Our results clearly reveal a greater propensity for transfer of energy from the Elasto-Gel pack to the skin-pack interface between minutes 0 and 4. We find this to be of great importance clinically. Stillwell (1972) claims a minimal length of 20 minutes is physiologically sound for the duration of a heat treatment, while Lehman (1982) states that temperature must be elevated to between 40 to 45 degrees Celsius (104-113 degrees Farenheit) to be of therapeutic value. Above this range, there is potential for tissue damage. Below 40 degrees C., heating is considered to by only mild. If the rate of temperature increase is very slow, then the amount of heat added could be balanced out by the convective effect of cooler blood. Thus, therapeutically effective levels may not be obtained. (Michlovitz, 1986)

The second point we find relevant concerning heat transfer is the physical property of the modality to adequately cover the area to be treated. This study was done with both packs of equal size. The disadvantage of the Silica gel packs were found to be the bulkiness resulting from the layers of towels necessary for its clinical use. This in itself hinders a close contact of the pack to skin in bony areas of the body surface. The Elasto-Gel product is a more pliable and conforming type of gel material which allows for more surface contact of the body and its irregular surfaces. Elasto-Gel also has the advantage of the use of only one towel which does not hinder the product's ability to conform. The product is made to fit over particular areas of the body such as ankles, shoulders, cranium, knees and elbows. This is beneficial as it allows for a more intimate and greater area of contact between the modality and the area to be treated.

We feel this comparison of Elasto-Gel and Silica gel as heating modalities has shown that both have comparable physiologic effects for their clinical usage. Variation between the packs have been presented, and it is felt by the researchers that the choice of pack for clinical use depends upon the methods of heating available, as well as the area of the body to be treated. The Elasto-Gel product can be

heated in a conventional oven, microwave oven or in a hydrocollator. Difficulties were encountered in this study with the hydrocollator method of heating, since plastic bags do have the potential for ripping in the hydrocollator or melting in the hot water. Yet, if a bony or irregular surface is to be treated with a heat modality, there is a great benefit from using Elasto-Gel due to its better conforming property.

SUMMARY

In conclusion, the results of our study show there is no statistical difference between the Elasto-Gel and standard Silica gel hot packs after the initial 4.5 minutes of the treatment procedure. Elasto-Gel did reach its peak temperature at a faster rate than did Silica gel, thus giving it a slight advantage in thermal conductivity.

MEAN TEMPERATURES (F.)
WITH STANDARD DEVIATIONS

	ELASTO GEL		SILICA GEL	
Minutes	Mean	SD	Mean	SD
0	91.34	2.94	87.75	1.20
1	101.53	3.39	92.73	2.09
2	104.95	3.49	99.59	1.75
3	106.94	3.15	103.95	1.74
4	107.48	2.12	106.97	1.72
5	108.27	1.99	108.64	1.65
6	108.75	1.89	109.34	1.62
7	109.06	1.74	109.64	1.58
8	109.06	1.69	109.88	1.50
9	109.11	1.43	109.88	1.44
10	108.92	1.42	109.72	1.43
11	108.67	1.27	109.59	1.31
12	108.45	1.16	109.38	1.27
13	108.27	1.12	109.05	1.27
14	108.02	1.13	108.73	1.29
15	107.77	1.16	108.44	1.25
16	107.55	1.17	108.14	1.27
17	107.27	1.15	107.83	1.22
18	107.08	1.16	107.58	1.25
19	106.86	1.14	107.33	1.15
20	106.67	1.13	107.11	1.21
21	106.47	1.15	106.83	1.19
22	106.38	1.14	106.67	1.14
23	106.23	1.16	106.47	1.18
24	106.08	1.15	106.33	1.17
25	106.02	1.16	106.14	1.10
26	105.89	1.13	106.05	1.08
27	105.78	1.14	105.86	1.09
28	105.64	1.14	105.70	1.06
29	105.58	1.20	105.58	1.10
30	105.45	1.16	105.48	1.13

TABLE 1

ANALYSIS OF VARIANCE

Source of Variation	SS	DF	MS	F
Error 1	269.26	30	8.98	
Pack	1.53	1	1.53	.17
Error 2	205.58	180	1.14	
Time	9080.92	6	1513.49	1325.17*
Pack by Time	113.27	6	18.88	16.53*

TABLE 2

* Indicates p< .01.

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