A Quasi-Experimental Study Examining the Safety Profile and Comfort Provided by Two Different Blanket Temperatures

Lori T. Sutton, BSN, RN, CPAN, CCRN, Faye S. Baker, BSN, RN, CPAN, Nan J. Faile, MS, RN, CCRP, Abbas Tavakoli, DrPH, MPH, ME

Surgical patients are often covered with warm blankets to alleviate the discomfort of feeling too cold in the perioperative environment. The goal of this study was to provide evidence to guide institutional blanket warming policies by examining blanket thermal behavior and blanket temperature preference of postoperative patients. The hypothesis was that 155°F blankets are safe for patient use and provide a higher level of thermal comfort to perioperative patients than do 110°F blankets. A sample of 156 adult participants was randomized to the intervention group (n = 76), who received 155°F blankets, or the control group (n = 80), who received 110°F blankets. Participants were covered neck to toe with the blankets in the postanesthesia care unit, and measurements were obtained for 10 minutes. An infrared thermometer was used to measure skin and blanket temperatures, and a numeric scale was used to measure thermal comfort. Blanket cooling rates were examined along with the effect of blanket temperatures on participants' skin temperature, oral temperature, and thermal comfort rating. Mean blanket temperatures for both groups were less than 93°F two minutes after application. The intervention group showed higher skin temperatures and thermal comfort throughout 10 minutes of data collection. The results of this study support the hypothesis that it is safe to cover surgical patients with 155°F blankets. Results also indicate a correlation between 155°F blankets and higher skin temperature and thermal comfort.

Keywords: *thermal comfort, blanket, PACU, temperature, research.*

FEELING COMFORTABLY WARM is an important aspect of overall comfort for patients in health care facilities. Warmed cotton blankets are used to provide thermal comfort to patients in various hospital departments as well as in outpatient centers and physician offices. In the perioperative area, patients often complain of feeling too cold before and after surgical procedures secondary to cool ambient room temperatures, decreased physical activity, and thin hospital gowns. This perception of cold may or may not be associated with hypothermia, which is defined as a core temperature at or below 96.8°F (36°C).[1] For patients who perceive cold when normothermic (core temperature greater than 96.8°F), warmed blankets are a passive warming measure that increase the feeling of warmth by interfering with heat loss from the skin to the environment.[2]

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It must be emphasized that passive warming with cotton blankets is appropriate only for normothermic patients who express subjectively feeling cold. Warmed blankets do not increase the core body temperature. Anesthetized patients can become poikilothermic[3] and be at high risk for development of hypothermia. For such patients, active warming with forced air devices and warmed fluid infusions are indicated to maintain or restore normothermia.[1]

Many patients describe the feeling of being cold as the worst aspect of the hospital experience and more unpleasant than pain. Frank et al[4] describe research indicating thermal comfort is influenced more by skin temperature than by core temperature. They hypothesize this to be an adaptive mechanism that triggers heat-conserving behaviors such as adding layers of clothing. According to this theory, the drive to achieve thermal comfort may actually prevent heat loss and subsequent hypothermia.

In addition to being unpleasant, the perception of feeling cold is physiologically stressful and can trigger autonomic effects that increase postoperative complications. A patient who feels too cold can experience shivering, which increases heart rate and blood pressure.[5]

Warming cabinets are designed specifically to warm blankets used for patient care. Historically, warming cabinet temperatures have been set arbitrarily. The warming cabinet temperature setting became controversial in 2005 when the Emergency Care Research Institute (ECRI) recommended that the temperature setting for cabinets used to warm patient blankets be limited to a maximum of 110°F. The ECRI recommendation describes reports of patients receiving burn injuries when they were covered with blankets that were too hot. However, in the article recommending the 110°F limitation, the ECRI offered no specific details of injuries related to warmed blankets.[6] The authors of this article contacted ECRI to request further details regarding injuries caused by warmed blankets. The ECRI representative responded that no other information was available.

ECRI identified the practice of storing patient care liquids, such as those used for infusions and surgical irrigations, in blanket cabinets as the primary thermal injury hazard prompting the 110°F recommendation. Because the thermal properties of water cause it to be more dangerous than blankets, ECRI research focused on establishing 110°F as a safe temperature for infusion and irrigation fluids. Results indicated a danger of patient burns from sustained skin contact with bottles of liquid heated to greater than 110°F; therefore, the recommendation of that temperature as the maximum temperature for heating patient care fluids. ECRI recommended the same maximum temperature for blankets because they are frequently stored in the same cabinet with fluids.[6] Compliance with the ECRI 110°F temperature limit for blanket warming cabinets has been recommended by nursing organizations including the Association of PeriOperative Registered Nurses (AORN) and the American Society of PeriAnesthesia Nurses (ASPAN).[7,8]

The safety of warming blankets to higher than 110°F is supported by evidence: the known physiology of burn injuries, the known physics of heat transfer from cotton blankets to skin, and previous nursing research demonstrating rapid blanket cooling on removal from the warmer. This evidence will be discussed in the following paragraphs.

Heat causes burn injury by causing coagulation and circulatory stasis in tissue.[9] Actual research demonstrating temperature and exposure time necessary to burn human skin is scarce. Most publications related to thermal injury cite the seminal thermal injury research published by Moritz and Henriques[10] in 1947. Moritz and Henriques circulated heated water through tubes placed in contact with live pigskin and measured the length of time required to cause skin injury at various temperatures. They found that 48°C (118.4°F) was the lowest temperature that could cause injury more severe than simple redness. Edlich et al[9] cite a temperature/length of exposure relationship depicted in Figure 1, based on Moritz's and Henriques' 1947 findings. Edlich et al[9] found that 111.2°F is a critical temperature: if maintained for longer than 6 hours, it will cause a cutaneous burn. Note that a temperature of 129.2°F (54°C) must be maintained for 1 minute to cause injury and 123.8°F (51°C) must be maintained for 15 minutes to cause injury.

In order for a cutaneous burn to occur, heat energy must be transferred from a warmer substance to

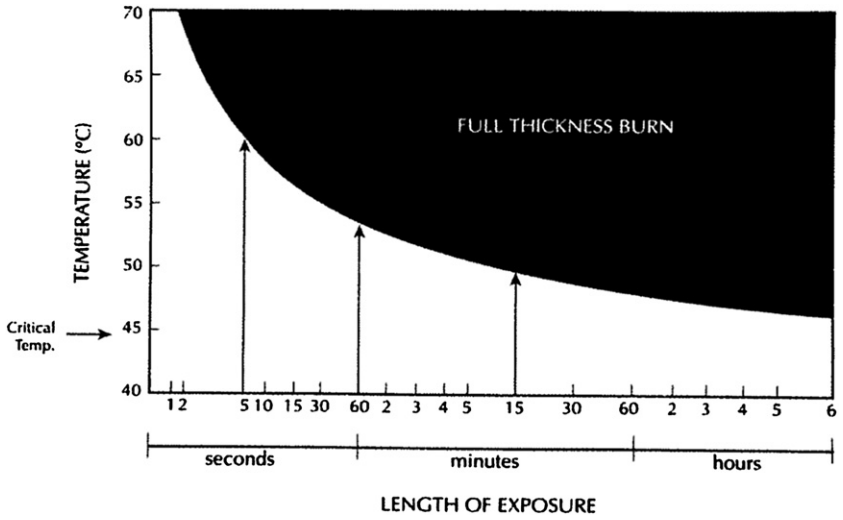

Figure 1. Relationship between temperature and duration of exposure in development of full-thickness burn injury. Reprinted with permission.[9]

the skin. The amount of heat energy transferred by one substance to another depends largely on the important physical property known as specific heat. Specific heat refers to the amount of heat energy required to raise the temperature of one gram of substance by one degree Celsius. Water can gain or lose a large amount of heat energy with very little change in its temperature because of its high specific heat. "Even if the initial temperatures of two materials are identical, the stored heat energy available from water is much more likely to produce a severe injury because the specific heat of water (the most common cause of scald burns) is the highest of all the gases, metals, and solids so far tested, with the exception of ammonia and ether."[9]

Moon[2], a biomedical engineer, applies the physics of heat energy transfer to the fluid and blanket question. The specific heat of water and skin is very similar because skin is mostly water. When a container of water-based fluid is placed in contact with skin, the cooler substance will absorb heat from the warmer substance until the temperatures meet halfway between the initial temperatures—the only heat energy lost being to the air or carried away by circulatory flow. Cotton blankets, on the other hand, differ from skin because blankets are mostly cellulose. A large amount of air contained in the fabric weave causes cotton blankets to have approximately the same specific heat as air. Moon[2] explains how to use theoretical physics to determine how heat transfers between blanket and skin. By his calculation, if a 93°C (200°F) blanket is placed on 33°C (91.4°F) skin, the skin temperature will only rise to 33.8°C (92.8°F), well below the skin temperature necessary to incur a thermal injury.

Blankets are not generally heated to a temperature as high as 93°C (200°F) as described in Moon's calculation.[2] Blog entries report warming cabinet temperatures between 140°F and 180°F.[11] Kosson et al[12] published a study describing the measurement of cooling rates for blankets heated to 145°F in warming cabinets. Budjoso[13] describes researching blankets heated to 150°F.

Kosson et al[12] measured the rate of cooling for 145°F blankets at specific intervals after removing the blankets from a warming cabinet. Average blanket temperatures ranged from 91°F to 118°F, 86°F to 105°F, and 85°F to 105°F at 0, 30, and 60 seconds, respectively. Importantly, after 30 seconds, none of the blankets were hotter than 105°F, less than the critical temperature of 111.2°F indicated by Edlich et al[9] in Figure 1. Although limited by small sample size and scientific rigor, the Kosson et al[12] findings indicate that the blankets immediately lose large quantities of heat energy when exposed to ambient air and do not remain hot long enough to burn patients. The authors recommended that other nurses

conduct similar studies to further establish the safe temperature setting for blanket warming cabinets.

Budjoso's[13] study compared 110°F blankets with 150°F blankets. The study examined rate of blanket cooling and perceived warmth experienced by a sample of three volunteer female health care workers. Blankets starting at 110°F decreased to a mean temperature of 103°F at application, 90°F by 1 minute, and 83°F by 5 minutes. The 150°F blankets decreased to a mean temperature of 138°F at placement, 100°F by 1 minute, and 84°F at 5 minutes. By the end of the data collection time, all blankets approached room temperature. The author also measured perceived warmth and found that participants rated perceived warmth higher with the higher temperature blankets.[13] Limitations noted with this study include small sample size and possible participant bias.

After institutions complied with lowering blanket temperatures to the 110°F recommendation, ECRI received numerous complaints that 110°F blankets lacked necessary warmth to relieve chilling of hospitalized patients. In 2009, responding to numerous requests to increase maximum allowable blanket temperature, ECRI issued a new recommendation that blankets could be warmed to 130°F. ECRI stated that the higher blanket temperatures were safe because of increased awareness of the need to store liquids at a lower temperature separately from blankets. This revised ECRI recommendation does not describe any research conducted to support the selection of 130°F as the safe or optimum temperature.[14]

Methods

The purpose of this study was to further examine the safety profile for warmed cotton blankets and determine a temperature that provides thermal comfort that is acceptable and safe for the patient. Two warming cabinet temperature settings were compared to determine baseline blanket temperature effect on blanket temperature change, skin temperature change, and patient comfort level.

This study was conducted in a 26-bed postanesthesia care unit (PACU) in a 384-bed metropolitan medical center. The perioperative area performs approximately 16,000 surgeries per year. Two warming cabinets were used, one with a 155°F thermostat setting and one with a 110°F thermostat setting. The cabinets both have upper and lower doors. The blankets used for all phases of this study are commonly referred to as bath blankets; they are thin, 100% cotton blankets stored folded to 16-ply in the warming cabinets.

A newly purchased Fluke 63 laser-guided, infrared, instant read thermometer (Fluke Corporation, Everett, WA) was used to measure all surface temperatures sampled. To measure the temperature of an object with the Fluke 63, one only needs to aim and squeeze a trigger. The thermometer emits a laser to light the object's surface at the measurement point. Designed specifically for noncontact temperature measurement, it displays a digital temperature readout measured from infrared energy radiated by the object's surface. This type of thermometer was recommended as the most accurate method for surface temperature measurement by our biomedical technician and has been used in prior studies.[12,13] The Fluke 63 was calibrated when manufactured, and its accuracy is certified in accordance with standards set by the National Institute of Standards and Technology. Additionally, the laser causes the participant no discomfort because it cannot be felt.

Oral temperatures were measured with the Welch Allyn SureTemp Plus oral thermometer (Welch Allyn Inc, San Diego, CA). The oral temperature route was chosen because ASPAN cites "strong evidence that it is the peripheral route that best approximates core temperature."[1] Welch Allyn oral thermometers are used routinely for patient temperature monitoring in our PACU and are calibrated yearly by the in-house biomedical department.

Thermal comfort was rated on a numeric scale (Figure 2) from 0 (intense cold) to 10 (intense warmth). This thermal comfort scale was adapted from a scale used to research thermal comfort provided by heated and cooled automobile seats. This type of scale is commonly used in the environmental comfort industry.[15] The thermal comfort scale is also similar to the perceived warmth scale described by Budjoso.[13] The scale was shown and explained to participants at the time of consent.

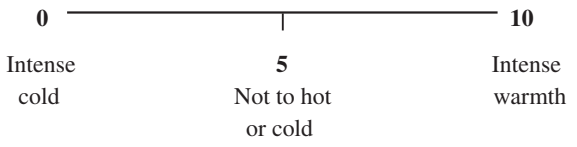

Figure 2. Thermal comfort scale.

Three phases of blanket pretesting were conducted to demonstrate blanket safety to Nursing Administration and the Institutional Review Board before enrolling patients in the study. The phase 1 pretest investigated the maximum temperature blankets would attain in each warming cabinet. This pretest began at 7 p.m. one evening. A principle researcher emptied both cabinets and then filled each cabinet with room temperature blankets until full. The door was taped shut to prevent opening by other staff. An assistant researcher was trained by the principle researcher to obtain hourly temperature measurement of blankets in each cabinet for 12 hours. The cabinets were kept closed as much as possible, then quickly opened, and temperature was measured at the top, middle, and bottom of each stack in each cabinet.

Pretest phase 2 measured the temperature of each blanket in each cabinet after allowing time for maximum temperature to be attained. This was done to determine the variability of blanket temperatures with regard to location within the cabinet. First, temperature indicated by the cabinet's digital readout was recorded. Then temperature of each inner cabinet wall was measured, followed by measurement of the temperature of the top and bottom of each folded blanket in the cabinet.

Pretest phase 3 assessed rate of cooling for blankets removed from the 155°F cabinet. In this phase of testing, researchers began by estimating room temperature by measuring the temperature of an interior wall surface next to the stretcher being used for testing. Temperature of the bed surface was then measured. Blanket temperature was assessed just prior to removing the blanket from the warmer. Two blankets were removed, and the still-folded blankets were carried approximately 18 feet to a stretcher. Two primary investigators worked together to quickly unfold the blankets on the bed until they were double thickness lengthwise and overlapped in the manner in which they are used to cover patients in this PACU. The warm blankets were then completely covered with two overlapping room temperature blankets. The blankets were quickly lifted, and warmed blanket surface temperature was measured immediately on completion of layering, then each minute for a total of 5 minutes.

The patient testing phase of this study was approved by the Institutional Review Board. Informed consent was obtained from each study participant. A convenience sample of 156 participants took part in the patient testing phase. Our statistician calculated that a sample of 100 to 150 would provide sufficient power to minimize the chance of making a type II error. The researchers used a quasi-experimental design to compare the two temperature settings: 155°F (intervention group, $n = 76$) and 110°F (control group, $n = 80$). Participants were randomly allocated to one of the two groups using a computerized random number generator. A coin flip was used to determine that even-numbered participants would be the control group and odd-numbered participants would be the intervention group.

Exclusion criteria included oral temperature below 96.8°F or greater than 100.4°F. These temperatures indicate hypo- or hyperthermia as defined by ASPAN standards and would require intervention to restore normothermia.[1] Participants were excluded if an oral temperature could not be measured for any reason or if unable to communicate with the researchers as required for the thermal comfort assessment. For example, non-English speaking participants or unresponsive participants were excluded. Other participants also were excluded because of scheduling conflicts.

Data were collected during the morning or early afternoon. The warming cabinets were stocked in the evening before data collection days to assure that blankets had reached maximum temperature prior to data collection. During data collection, the upper cabinet was used to obtain blankets only for study participants. The upper cabinets were taped shut to prevent other staff from opening the cabinet and allowing unnecessary heat loss from the blankets.

Each participant received standard preoperative and intraoperative care, and data collection began when the participant arrived in the PACU. First, oral temperature was measured and the absence

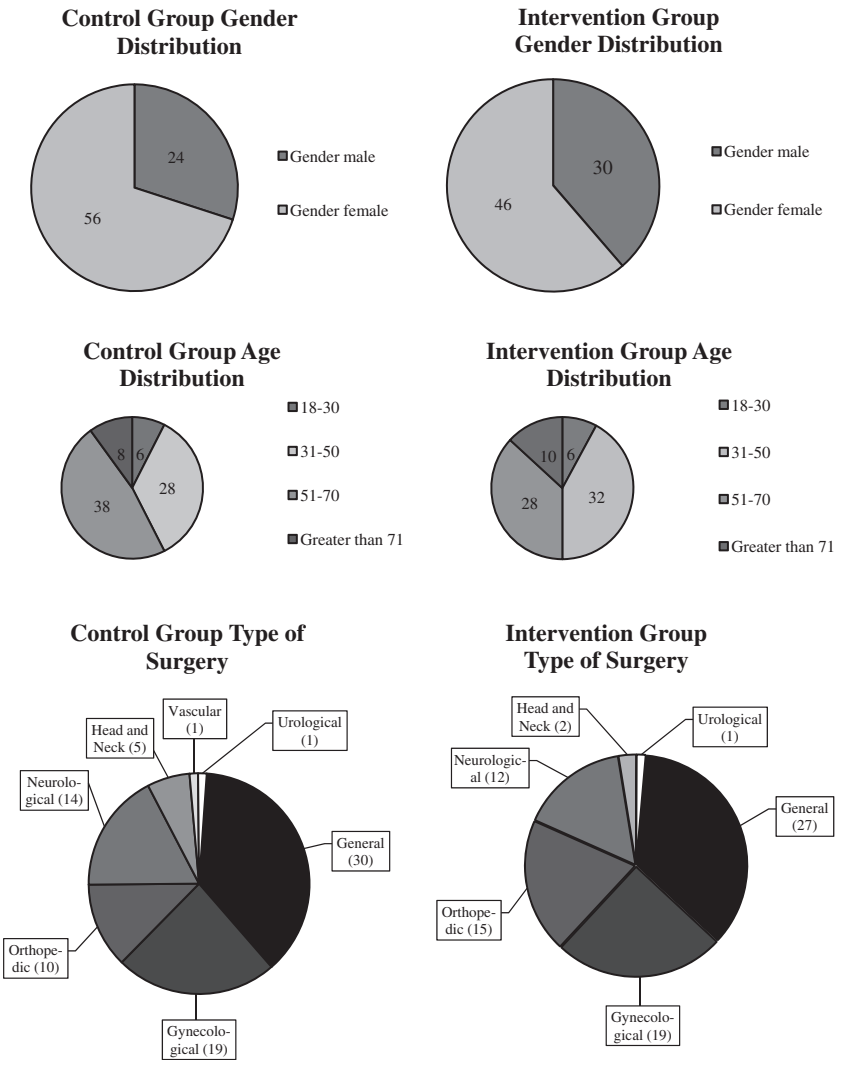

Figure 3. Blanket study demographic distribution.

of other exclusion criteria was verified by the researchers. Baseline skin temperature was measured at a spot on the forearm, and the participant was asked to rate numeric thermal comfort. The researcher then obtained two blankets from the appropriate warming cabinet. All staff and the participants except the researchers were blinded to the starting temperature of the blanket. The blankets were quickly unfolded and placed directly on the participant in an overlapping fashion, covering the participant from neck to toe. The warm blankets were then covered with two room temperature blankets. Immediately, all blankets were quickly lifted to measure forearm temperature (application measurement) at approximately the same location as baseline. Then the blanket temperature was measured from where it had been in contact with the forearm. The arm was then recovered with the blankets. Skin and blanket temperature measurements were repeated at the same location every minute thereafter for 10 minutes. Thermal comfort rating was reassessed at 5 and 10 minutes. Oral temperature was repeated at the end of the study. Data collection for the participant was then complete.

Statistical analysis was done on human testing data. Categorical variables were analyzed using frequency distributions; in addition, graphs (pie and line) were used to illustrate the characteristics of control group and intervention group participants. Data analyzed over time included oral temperature,

skin temperature, blanket temperature, and comfort level. For continuous variables, statistics were used to compute measures of central tendency (mean and median) and measures of spread (standard deviation and range). Because so many data were being gathered over a span of time, General Linear Model (GLM) analyses in SAS and MIXED procedures (mixed linear model that allows statistical inferences about data) for continuous outcomes (skin temperature, blanket temperature, oral temperature, and comfort level) were used to examine the effects of time, group, and time by group interaction. Data were statistically analyzed at four points during the study: at baseline, application time, 5 minutes, and 10 minutes.

Analysis of time effect refers to the mean of all participants at time 1 (baseline) compared with all participants at time 2 (blanket application). Analysis of group effect refers to the mean of all control group participants at times 1 and 2 compared with the mean of all intervention group participants at times 1 and 2. Analysis of time by group interaction effect refers to comparing each group at each time with each other group at each other time.

Results

Phase 1 pretesting demonstrated that the blankets warmed at different rates, depending on their location in the warming cabinet. Baseline temperature of the blankets was 71°F. Table 1 summarizes the measurements from phase 1 pretesting.

When the temperature of each blanket was measured in pretest phase 2, it was discovered that there was variability of blanket temperature depending on location within the cabinet. These data are summarized in Table 2.

Phase 3 pretesting showed that mean temperature of blankets before removal from the 155°F warmer was 148.8°F. The researchers were amazed to find that in the time it took to carry the blankets to the stretcher and open them, the mean temperature had already dropped to 119.4°F, a decrease of 29.4°F. Within 30 seconds after opening, the mean temperature of the blanket dropped to 107.6°F and by 1 minute to 104.5°F. At completion of phase 3, after 5 minutes, mean blanket temperatures were 96.8°F.

Of the 156 participants enrolled in the human testing portion of the study, 80 were randomized to the control group and 76 were randomized to the intervention group. Figure 3 illustrates demographic details of the groups. Level of significance was $P \leq .05$ for all statistical analyses.

The mean oral temperature for the control group was 97.84°F at baseline (time 1) and 97.85°F at 10 minutes (time 2). The mean oral temperature for the intervention group was 97.91°F at baseline and 97.86°F at 10 minutes. Table 3 contains GLM results and illustrates that there were no significant differences in oral temperature means at any time during data collection.

Table 1. Pretest Phase 1: Time to Maximum Temperature and the Maximum Temperature Achieved

	110°F cabinet		155°F cabinet	
	Upper Cabinet		Upper Cabinet	
	Time to Maximum Temperature	Maximum Temperature Achieved	Time to Maximum Temperature	Maximum Temperature Achieved
Top	6 h	112°F	2 h	156.5°F
Middle	9 h	113°F	6 h	145°F
Bottom	9 h	111.5°F	6 h	149°F
	Lower Cabinet		Lower Cabinet	
Top	8 h	109.5°F	9 h	158.5°F
Middle	9 h	111.5°F	11 h	148.5°F
Bottom	6 h	105°F	6 h	144°F

Table 2. Variability of Blanket Temperature in Cabinet

Item Measured	110°F Cabinet Upper Cabinet	155°F Cabinet Upper Cabinet
Thermostat reading (°F)	109	159
Maximum wall temperature (°F)	111	147
Minimum blanket temperature (°F)	104	148
Maximum blanket temperature (°F)	109	157
	Lower Cabinet	**Lower Cabinet**
Thermostat reading (°F)	109	158
Maximum wall temperature (°F)	111	151
Minimum blanket temperature (°F)	94	129
Maximum blanket temperature (°F)	111	148

Mean numeric thermal comfort rating was similar for both groups at the beginning of data collection. Mean control group comfort level was 4.80 at baseline (time 1), 5.01 at 5 minutes (time 2), and 5.14 at 10 minutes (time 3). Mean intervention group thermal comfort was 4.87 at baseline (time 1), 5.55 at 5 minutes (time 2), and 5.57 at 10 minutes (time 3). Comfort rating increased for both groups throughout testing, but the intervention group reported a slightly higher mean comfort level at 5 and 10 minutes than the control group. Figure 4 graphs minimum and maximum thermal comfort for both groups, and Figure 5 graphs mean thermal comfort for both groups.

GLM analysis shows that there was not significant time by group effect for comfort level. There was, however, significant time effect and group effect for comfort level. Table 4 details results of this analysis.

Table 3. Oral Temperature Statistical Analysis

Relationship Analyzed	*P* Value of Oral Temperature
Time	.5833
Group	.5501
Time by group	.3566

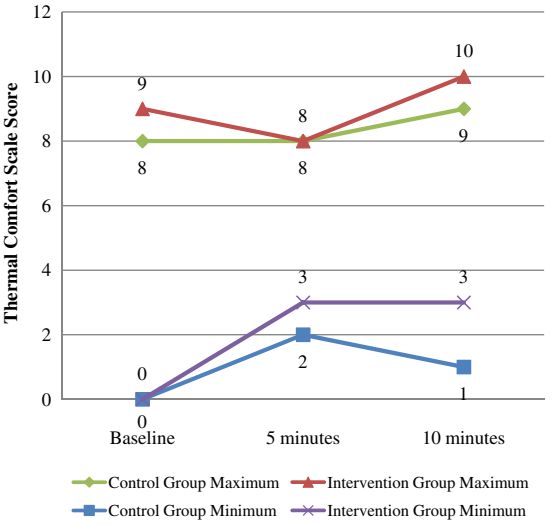

Figure 4. Minimum and maximum thermal comfort. This figure is available in color online at www.jopan.org.

The human testing phase correlated with pretesting phase results for blanket temperature decrease. Blankets from both groups lost a great deal of heat instantly on removal from the cabinet. Mean control group blanket temperature decreased from 111.04°F at baseline (time 1) to 90.65°F at application (time 2) and then to 87.78°F at 10 minutes (time 3). Mean intervention group blanket temperature decreased from 152.97°F at baseline (time 1) to 100.43°F at application (time 2) and then to 88.66°F at 10 minutes (time 3). Figure 6 graphs

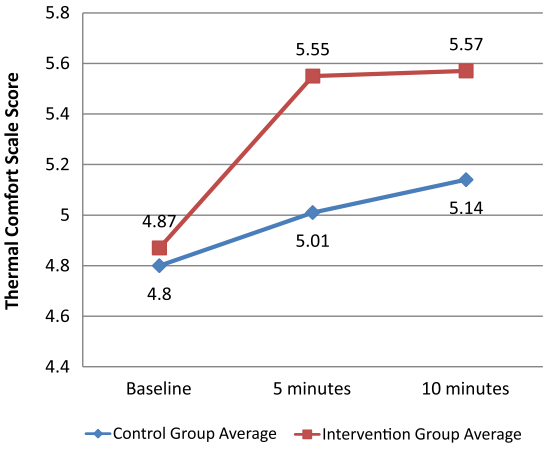

Figure 5. Average thermal comfort. This figure is available in color online at www.jopan.org.

Table 4. Thermal Comfort Statistical Analysis

Relationship Analyzed	*P* Value of Thermal Comfort
Time	.0451
Group	.0018
Time by group	.1767

control group blanket temperature changes, and Figure 7 graphs intervention group blanket temperature changes.

GLM analysis compared baseline with time 1 and showed that there were significant effects when comparing blanket temperature means for all time, group, and time by group interactions. Table 5 summarizes analysis of blanket temperature effects.

Intervention group participants had greater mean skin temperature increase than did control group participants. Overall, the mean skin temperature for the control group increased from 87.68°F at baseline (time 1) to 89.18°F at application (time 2). The average skin temperature for the intervention group increased from 86.97°F at baseline (time 1) to 89.97°F at application (time 2). Figure 8 illustrates minimum and maximum skin temperatures, and Figure 9 illustrates mean skin temperatures for each group at each minute. Note that by the end of data collection, temperatures for both groups are similar.

GLM analysis compared baseline with time 1 and showed that there was significant time effect for skin temperature. We cannot, however, conclude that there is a different change over time for the treated group versus the control group. Detailed *P* value analysis of skin temperature means are listed in Table 6.

Discussion

Conducting this study in a busy PACU was a great challenge for the researchers. Scheduling was complicated because the researchers had to preoperatively identify patients who would arrive in the PACU during the time allotted for data collection. The researchers subsequently had to identify when those patients would be present for the preadmission interview so that informed consent could be obtained at that time. Sometimes, consenting and data collection were occurring in different departments at the same time, requiring great coordination of efforts among the researchers.

There were 213 individuals consented for the study and data were collected from 156 participants. Reasons for exclusion included scheduling conflicts (27), surgery cancellation (8), fast-track to Phase II (8), hypothermia (6), withdrawal from study (4), inability to communicate (3), and data collection error (1).

Although participants were randomly assigned to intervention or control groups, resulting demographic distribution was very similar for the groups. Similarity of the groups increases the validity of the results for our population. The variety of age, gender, and types of surgeries increases the ability to generalize the results to the general adult population.

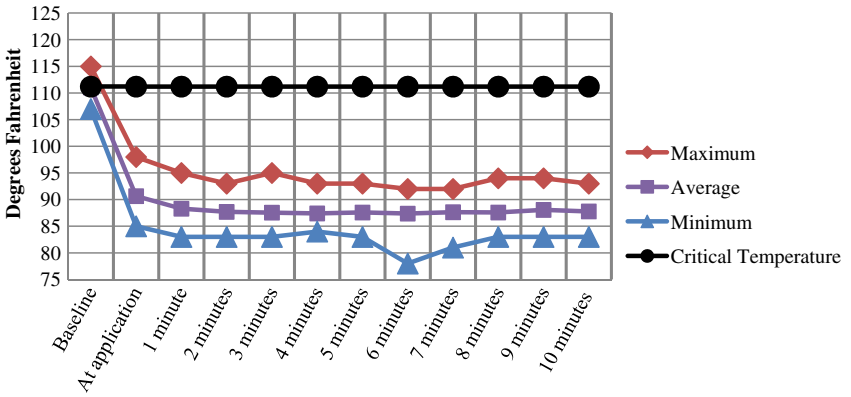

Figure 6. Control group blanket temperatures. This figure is available in color online at www.jopan.org.

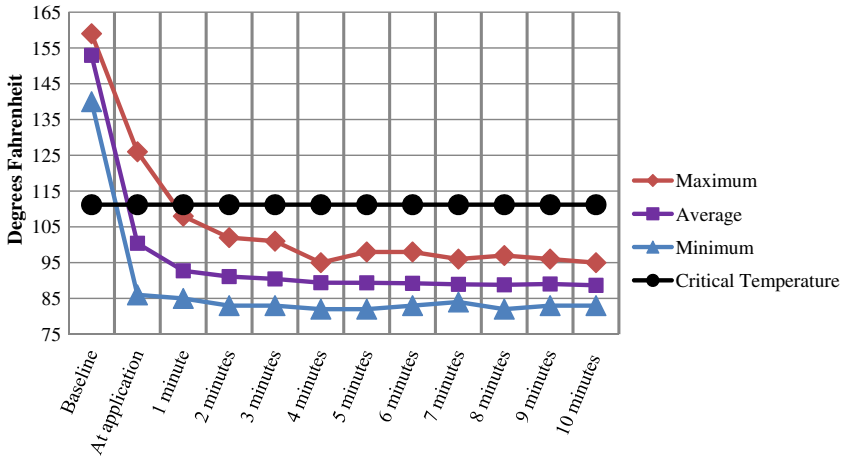

Figure 7. Intervention group blanket temperatures. This figure is available in color online at www.jopan.org.

Oral temperatures were only measured for purposes of establishing absence of study exclusion criteria. However, the lack of significant difference of the means reinforces the knowledge that warm blankets do not significantly affect core body temperature.

Comfort level time by group analysis did not yield significant results, but both time and group examination of the data did yield significant results. Importantly, when overall intervention comfort level mean was compared with overall control group comfort level mean, the intervention group showed a significantly higher mean thermal comfort level than control group.

Blanket temperature for both groups decreased very rapidly as soon as the blankets were taken out of the warmer. Maximum temperature of any blanket immediately after application to the patient was 126°F for the intervention group (mean, 100.43°F), and 1 minute later the maximum temperature had decreased to 108°F. The 108°F measurement is well below the critical temperature of 111.2°F that would need to be maintained for over 6 hours to cause a burn, as noted by Edlich et al.[9] These findings support the researchers' hypothesis that the intervention group blankets are safe for patient use and do not remain hot long enough to cause burn injuries.

The skin temperature increased for both groups over time; the skin temperature for both groups was significantly higher at time 1 as compared with any group at baseline. Based on information from Frank et al,[4] the rapid skin temperature increase may be responsible for the sensation of warmth experienced by individuals when covered with a warm blanket. Although not significant, when compared with the control group at the same time, the slightly higher skin temperature of the intervention group may also contribute to

Table 5. Differences of Least Squares Means for Blanket Temperature

Effect	Time	Group Status	Time	Group Status	*P* Value
Time	Baseline		1		< .0001
Group		Experimental		Control	< .0001
Time × group	Baseline	Experimental	Baseline	Control	< .0001
Time × group	Baseline	Experimental	1	Experimental	< .0001
Time × group	Baseline	Experimental	1	Control	< .0001
Time × group	Baseline	Control	1	Experimental	< .0001
Time × group	Baseline	Control	1	Control	< .0001
Time × group	1	Experimental	1	Control	< .0001

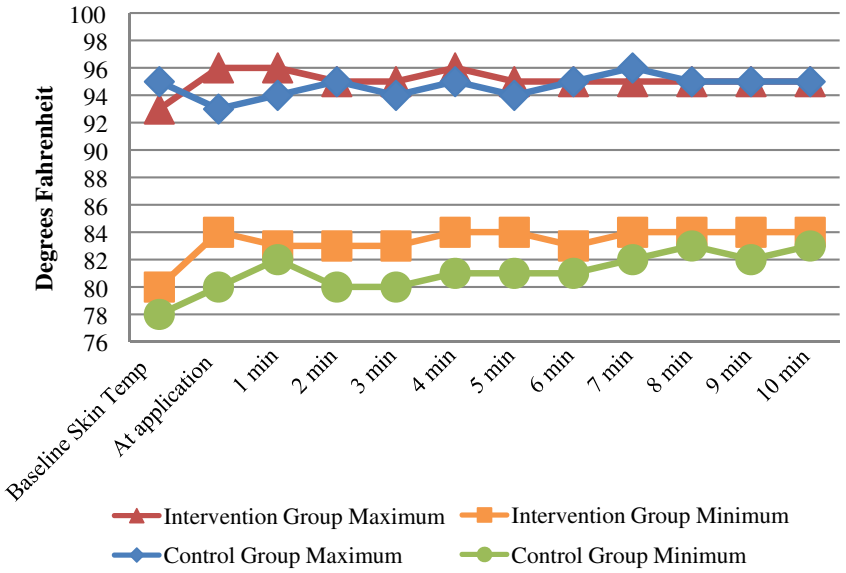

Figure 8. Minimum and maximum skin temperatures. This figure is available in color online at www.jopan.org.

the slightly higher thermal comfort rating they reported.

Conclusion

The rapid reduction in blanket temperatures supports the hypothesis that intervention group blankets do not pose a burn hazard to postoperative patients. The researchers conclude from these findings that blankets intended for patient use can be safely warmed in a cabinet set to 155°F.

Statistical calculations support the conclusion that sample size provided sufficient power to the study. The similarity in demographic distribution indicates that these results are generalizable to adult surgical patients.

Skin temperature increased for all participants from baseline to time 1, then to the end of sampling. The lack of significant time by group differences between control and intervention groups at a given time indicates that the

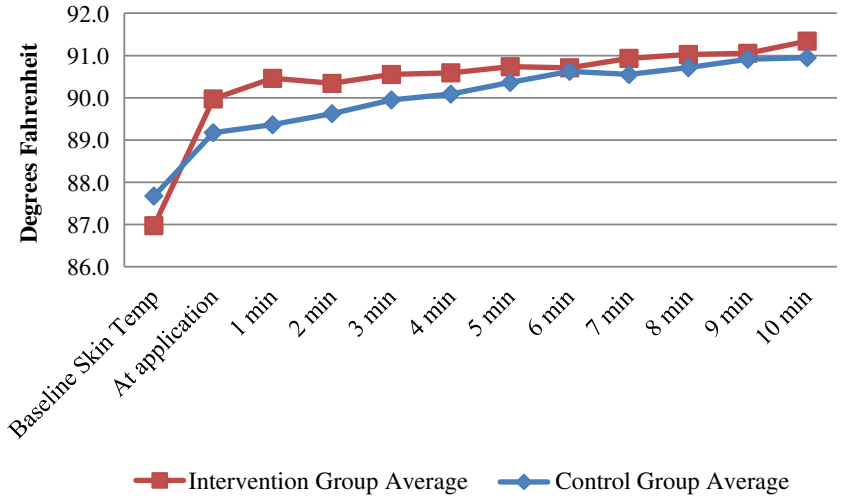

Figure 9. Average skin temperatures. This figure is available in color online at www.jopan.org.

Table 6. Differences of Least Squares Means for Skin Temperature

Effect	Time	Group Status	Time	Group Status	*P* Value
Time	Baseline		1		< .0001
Group		Experimental		Control	.9148
Time × group	Baseline	Experimental	Baseline	Control	.1728
Time × group	Baseline	Experimental	1	Experimental	< .0001
Time × group	Baseline	Experimental	1	Control	< .0001
Time × group	Baseline	Control	1	Experimental	< .0001
Time × group	Baseline	Control	1	Control	< .0001
Time × group	1	Experimental	1	Control	.0695

blankets from both groups exert a similar effect on the skin.

There was significant difference in mean thermal comfort analysis when all intervention group results were compared with all control group results. Overall, intervention group participants experienced a higher thermal comfort level throughout data collection.

Assisting individuals to achieve optimal comfort is one of the most important aspects of nursing practice. This study supports the conclusion that 155°F blankets are safe and provide a higher level of thermal comfort to postoperative patients. Nurses should have the option of providing 155°F blankets when doing so is assessed to be an appropriate intervention for patients.

References

1. Hooper VD, Chard R, Clifford T, et al. ASPAN's evidence-based clinical practice guideline for the promotion of perioperative normothermia. *J Perianesth Nurs*. 2009;24:271-287.
2. Moon JK. Warmed blankets are safe. Available at: http://www.enthermics.com/learn/pdfs/skin%20warming.pdf. Accessed July 17, 2009.
3. Johnson JS, Loushin MK. The effects of anesthetic agents on cardiac function. In: Iaizzo PA, ed. *The Handbook of Cardiac Anatomy, Physiology, and Devices*. New York, NY: Springer Science and Business Media; 2009:239.
4. Frank SM, Raja SN, Bulcao CF, Goldstein DS. Relative contribution of core and cutaneous temperatures to thermal comfort and autonomic responses in humans. *J Appl Physiol*. 2002;86:1588-1593.
5. Kurz A. Thermal care in the perioperative period. *Best Pract Res Clin Anaesthesiol*. 2008;22:39-62.
6. Emergency Care Research Institute. Hazard report. Limiting temperature settings on blanket and solution warming cabinets can prevent patient burns. *Health Devices*. 2005;34:168-171.
7. Petersen C. Clinical issues: Ignoring product label warnings. *AORN Journal*. 2006;83:944-949.
8. Clifford T. Frequently asked questions. *Breathline*. 2008; 28:12-13.
9. Edlich RF, Bailey TI, Bill TJ. Thermal burns. In: Marx JH, Hockberger RS, Walls RM, et al, eds. *Rosen's Emergency Medicine: Concepts and Clinical Practice*. 5th ed. St. Louis, MO: Mosby; 2002:801-813.
10. Moritz A, Henriques F. Studies of thermal injury. II. The relative importance of time and surface temperature in the causation of cutaneous burns. 1947. Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1934304/pdf/amjpathol00502-0018.pdf. Accessed July 29, 2009.
11. MacArthur S. Mac's safety space. Available at: http://blogs.hcpro.com/hospitalsafety/?s=ahh+the+fact+and+fiction+about+blanket&x=34&y=6. Accessed December 5, 2009.
12. Kosson C, Tveit C, Belew J. How warm are your blankets? Evidence challenges advisory. *Breathline*. 2009;29:6-7.
13. Budjoso PJ. Blanket warming, comfort and safety. *AORN Journal*. 2009;89:717-722.
14. Emergency Care Research Institute. Hazard report update ECRI Institute revises its recommendation for temperature limits on blanket warmers. *Health Devices*. 2009;38: 230-231.
15. Zhang YF, Wyon DP, Fang L, Melikov AK. The influence of heated or cooled seats on the acceptable ambient temperature range. *Ergonomics*. 2007;50:586-600.