Designing and Testing of Blankets for Thermoregulation

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Abstract

During the first half hour of their lives, neonates lose body heat rapidly. Promoting heat retention as well as allowing heat to reach the baby would benefit and help initiate neonatal thermoregulation earlier. There is limited research on alternative materials for effective thermoregulation of neonates. Prior to being placed under a radiant heater or incubator, babies are wrapped in a, typically cotton, blanket. The blanket not only provides the baby with comfort, but also helps it minimally retain heat and allow heat to permeate the surface. Emergency foil or Mylar blankets retain heat completely, but do not allow heat to penetrate them. Testing the normal blankets and the emergency blankets will provide for a temperature range to achieve better regulation of heat. In other words, an ideal amount of heat being lost per minute that will promote neonatal thermoregulation while at the same time allow the neonate to lose a little bit of heat to further encourage the regulation of body heat. Through the interweaving of the cotton and the Mylar blankets, a more efficient temperature control will be established. The foil blanket retained the heat, and the cotton blanket allowed heat in, providing for a balance that will promote neonatal thermoregulation during the first half hour of life. The ability to hasten the regulation of heat loss and heat gain will efficiently higher the chances of the survival of the neonate. The results indicate that the design of the blanket retained heat well, but had the same heat loss as the foil blanket, which is an indicant that the cotton blanket did not allow environmental influence. Therefore, the heat retention was adequate, but heat loss was not.

Background

The miracle of childbirth has been taking place for centuries, and along with the birthing process, procedures of care have also changed. The care provided to the neonate is impertinent to their health. It is not uncommon to find the general public's impression of the delivery of a child to be that of a child being born, dried off, wrapped in a blanket and handed to their mother. However, not much is given to what comes afterwards. After a baby is delivered and the airway is clear and functional, after being dried off, they are typically given to their mother to come in skin-contact and initiate neonatal thermoregulation, amongst other important aspects, like breastfeeding. Many studies have shown that it is vitally important to keep the neonate warm so that neonatal thermoregulation can be established earlier. Thermoregulation maintains equilibrium between heat production and heat loss (de Broca, Kreville, Kremp, Leke & Risbourg, 1991). Prior to birth, the neonate relied on the mother for supplying warmth. Thermoregulation during prenatal life is the responsibility of the placenta which, functioning as a heat exchanger between fetal and maternal circulations, deprives the fetus of the opportunity to exercise control of his body temperature (Adamsons, 1965). Within the first half hour of life, the neonate is prone to lose the most heat. "Heat loss occurs in two stages: 1. The flow of heat from the center of the body to its surface. 2. The flow of heat from the body surface to the environment by conduction, convection, radiation or water evaporation" (de Broca, Kreville, Kremp, Leke & Risbourg, 1991, 121). The care provided during the first half hour of life influences the neonate's thermoregulation. A baby's ability to maintain a constant temperature is

Figure 1 – Delivery room

affected by the amount of brown adipose tissue it has, the cardiovascular system and amount of heat loss that is permitted to take place from its body surfaces (Jones, 1977). Most premature infants are born with less or underdeveloped brown adipose tissue, which serves for an even higher probability of heat loss. Brown adipose tissue is one of two types of fat tissue, the other type being white. Generating body heat is the primary function of the tissue, so that the newborn does not shiver. About 5% of the neonate's body mass is made of brown adipose tissue. It is located on the back, along the upper half of the spine and around the scapular area. Although the brown adipose tissue helps generate heat for the neonate, it does not initiate neonatal thermoregulation, but does play a key role in helping the baby regulate its body heat.

Neonatal Thermoregulation

The baby has no control over how much brown adipose tissue it has, so it is the responsibility of their caregivers to provide them with adequate heat sources. Thermal regulation is an important part of energy expenditure, especially for low birth-weight infants or preterm newborns (Hurgoiu, 1992). It has been demonstrated that delivery rooms kept at a temperature higher than 26 degrees Celsius also helps stimulate neonatal thermoregulation. In the initial minutes following birth the rate of fall of deep body and skin temperatures are about 0.1 degrees Celsius per minute and 0.3 degrees Celsius per minute, respectively (Adamsons, 2006). The heat loss a neonate experiences after birth calculates to almost 5 times more than an average adult's heat loss. Initial heat loss was due principally to evaporation, and whether or not establishment of breathing would be irregular or delayed if the initial cold stress was reduced. Heat loss due to radiation and convection together was twice that from evaporation. Wet infants exposed to room air lost nearly five times more heat than those who were dried and warmed (Dahm & James, 1972). There are many ways a neonate can lose heat. The higher ratio of body surface to body volume are proportional to heat loss to heat production, which means that the less body volume, but more surface area, the more heat lost. The inability to shiver also causes the baby to lose heat because the act of shivering produces heat, but due to the lower brown adipose, the neonate is unable to shiver. Being exposed to cold areas also leaves the baby at risk of losing heat. In pre-mature infants, and underdeveloped nervous system may not properly respond to the cold. Cold stress and hyperthermia may have serious metabolic consequences for all newborns (Çınar, 2006). Losing body heat can cause the neonate to become hypothermic which can also induce other complications, such as apnea. It is harmful to the neonate to become hypothermic, therefore the more body heat the neonate retains, the better. In premature infants, it is even more impertinent to regulate body heat. Premature infants need to attain both medical stability and maturational milestones (specifically, independent thermoregulation, resolution of apnea of prematurity, and the ability to feed by mouth) before safe discharge to home (Eichenwald, 2001). Before a baby is released from the hospital, it must learn how to regulate its body heat, for its own benefit. As the neonate retains more heat, they will adapt to regulate their own body heat, but until then, they really on their caregivers to provide them a beneficial heat source. Furthermore, it is of vital importance that a neonate can independently regulate its body temperature.

Incubators

Figure 2 – Neonate in incubator

Incubators are the method most people are commonly familiar with when it comes to warming newborns. They are designed to keep heat in by surrounding the baby with a plastic shell with holes on the sides, allowing access to the neonate. However, studies show that the incubator method to help neonates regulate their body heat has pros and cons. The incubators do allow heat to reach the baby, but the baby is just as prone to lose heat. The plastic shell also makes it difficult to access the baby. Severe temperature differences inside an incubator lead to neonatal heat loss, hypothermia and apnea, which are closely related to air flow and air velocity (Kim, Kwon, & Yoo, 2002). Therefore, the neonate will be negatively affected by the incubator. Wu & Hodgman measured the insensible water loss of babies in incubators and showed that it increased markedly with decreasing gestational age and was further increased by radiant heat (Hammarlund, Sjörs, & Sedin, 2008). A loss in water can also cause the neonate to dehydrate, and furthermore, it may cause the neonate to have a heat stroke.

Radiant Heaters

www.unimedica.net/index.php?id=15

Figure 3 – Radiant heater

Radiant heaters are another method used to help initiate thermoregulation and to keep a neonate warm. As stated, radiant heaters increase water loss in babies, more so than incubators. The infant lies on a mattress in a bassinette, the sides of which fold flat for ease of access. On his abdomen is taped a skin thermistor which controls the heat output from the heating canopy. The difference between the desired skin temperature (indicated by the operator) and the actual skin temperature, the proportional control system, controls the energy output to the heating device. Visual and auditory alarms are provided should the infant's temperature rise or fall unduly. However, just like the incubators, the radiant warmer has both positive and negative effects on the neonate's thermoregulation. When the neonate is placed under the radiant heater, there is better access to the baby to provide care. The warmer air around the baby helps keep the neonate's core temperature constant, but its skin temperature tends to fall. The continuous supply of servo-controlled infrared energy may be to reduce the status of the infant to that of a vulnerable poikilotherm. Also, since the baby is not surrounded by a shield, as in the incubator, there is a higher possibility of heat loss. "In vigorous infants, the simple maneuver of drying and wrapping in a warm blanket is almost as effective in diminishing heat loss as placing them under a radiant heater" (Dahm & James, 1972, 504).

Baby Blankets

After a baby is delivered, second to drying them off; they are wrapped in a blanket. Wrapping the neonate in the blanket helps the baby adjust to life outside the womb because it provides a similar feeling to that of what the neonate experienced whilst in the womb, bundled up in a warm area. The blankets also provide a little bit of warmth, but they do not retain any heat, and also lose just as much heat as the baby does on its own. So wrapping a baby in a blanket provides comfort, but does not really help it benefit regulation of its body heat. The present inventions of baby blankets pertain to providing warmth and comfort to an infant (Kliegl & Kliegl, 2002). The blanket's temperature is influenced by what it is wrapped around and what outside influence are acting upon it, such as a radiant heater. For example, when placed under a radiant heater the blanket absorbs the heat given off by the infrared lamp, and then since the blanket is warm, the baby wrapped in it is provided with warmth. However, when the baby is not under the radiant heater or in an incubator, then it is

http://babycottagegifts.com/images/thumbnails/2Pk_Thrml_Blnkt_Sage.jpg

Figure 4 – Neonatal blankets

prone to lose heat because the blanket is not keeping the heat. A baby blanket helps keep a baby warm, but ultimately, the baby is prone to lose heat as well.

Mylar Blankets

Figure 5 – Mylar blanket

Mylar blankets are designed differently than typical baby blankets. Baby blankets are made out of materials like cotton, where as Mylar blankets have properties similar to aluminum foil. The Mylar blankets design allows for better retention of heat, due to the materials that make it up. However, the properties also prevent from outer heat to penetrate the blanket. However, they also trap all the heat the body gives off. Mylar blankets have been studied in various medical settings. They were used in a study done on patients who had been put under anesthetics to see how they affected the post-anesthetic shivers. “We conclude that in spontaneously breathing patients, the use of a space blanket decreased the incidence of post-anesthetic shivering and patients' perception of cold, and resulted in higher skin temperatures, even after relatively short general anesthetics” (Buggy & Hughes, 1994). Mylar blankets are proven to retain heat more adequately than normal blankets, for that is their purpose. Unlike normal baby blankets, if a baby were placed under a radiant heater or in an incubator wrapped in a Mylar blanket, it would not benefit them. The structure of the Mylar blanket would prevent any of the external heat provided by the radiant heater or incubator to reach the baby. Nevertheless, also unlike the baby blanket, a Mylar blanket would keep the baby’s body heat cocooned around them, so they are surrounded by their own body heat.

Neonatal Heat Retention

Figure 6 – A baby who was just born

Neonates need a better method to help them retain their own body heat, as well as allow heat from an outside source to reach them, preferably during the first half hour of life, when they lose the most heat. Certainly the baby can be placed under an incubator or radiant heater, but the sooner the neonate comes in skin contact with the mother, the more likely neonatal thermoregulation is likely to initiate. The most adequate method would be to do what is done in most delivery rooms, wrapping the baby in a blanket. However, not just an ordinary baby blanket, but a blanket designed to help the neonate retain their own body heat, but allow heat from the outside to penetrate and also reach the baby. A blanket designed with the properties of a normal baby blanket and those of a Mylar blanket that will help a baby regulate its body heat in a more efficient manner. It is vitally important that a neonate adapt to regulating its body temperature as soon as possible post-delivery. Instigating neonatal thermoregulation is one of the first things a neonate does its first moments of life. The first half hour of their lives is under the most influence by the outside world due to the extent of the amount of heat they are prone to lose. There should be a mechanism to help them initiate neonatal thermoregulation more efficiently during that first half hour of life.

Materials

Supplies	*Equipment*
Cotton Gerber® Thermal Baby Blankets Emergency Baby Foil Blanket Water Bottle Medical tape Masking Tape	LabPro Sensor Device LoggerPro software Heat Probe

Procedure

Prior to running test, the blanket must be assembled. To begin assembling the blanket, acquire a cotton blanket and a foil blanket. The foil must then be cut into 1 inch strips. Then, 1 inch cuts should be made on the cotton blankets, each an inch apart from the others. After the strips have been cut, and the slits have been made, the strips need to be weaved into the cotton blanket, to create a weave pattern (See Figure 7).

Figure 7 – Weaving pattern of blanket

The primary step in the testing is to acquire a hot water bottle and temperature probe. Select a drill bit that has the same diameter as the temperature probe. Drill a hole in the top of the hot water bottle and insert the temperature probe. Fill the hot water bottle with water heated to 40°C. Attach the other end of the temperature probe to the LabPro sensor device, and attach the LabPro sensor device to a computer that has the LoggerPro software installed. Assure that the temperature reads 40.0°C. Select the 'Experiment' tab and then select 'Data Collection'. Set the trials to run for 30 minutes, taking 5 samples per minute, 0.02 minutes apart. Place the hot water bottle into the refrigerator and select 'Collect' on the software. Let the test run for 30 minutes. Save the results. (See Figure 8)

Test the other blankets by repeating similarly by re-filling the hot water bottle with 40°C water again. Run another trial for 30 minutes. Repeat until 5 trials are recorded. Then run 15 more trials, but 5 while the hot water bottle is wrapped in a cotton blanket, 5 when it is wrapped in the foil blanket, and 5 when it is wrapped in the novel blanket. It is essential to save all the data.

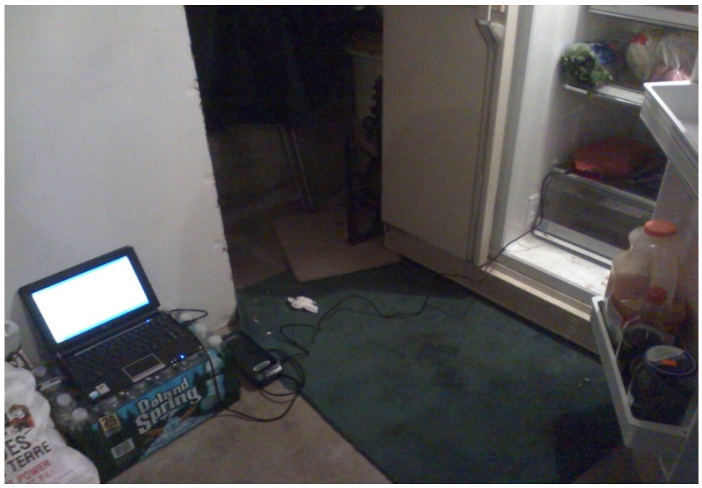

Figure 8 – General set-up of testing

The data must then be put into Microsoft Excel, and find the averages for each ending blanket’s ending temperature. Taking this, run the SPSS software, and run a Tukey HSD, Greenhouse-Geisser, and Wilks Lambda test in order to analyze the significant differences between temperature changes, and overall heat retain ability of the blankets.

Data

Figure 9

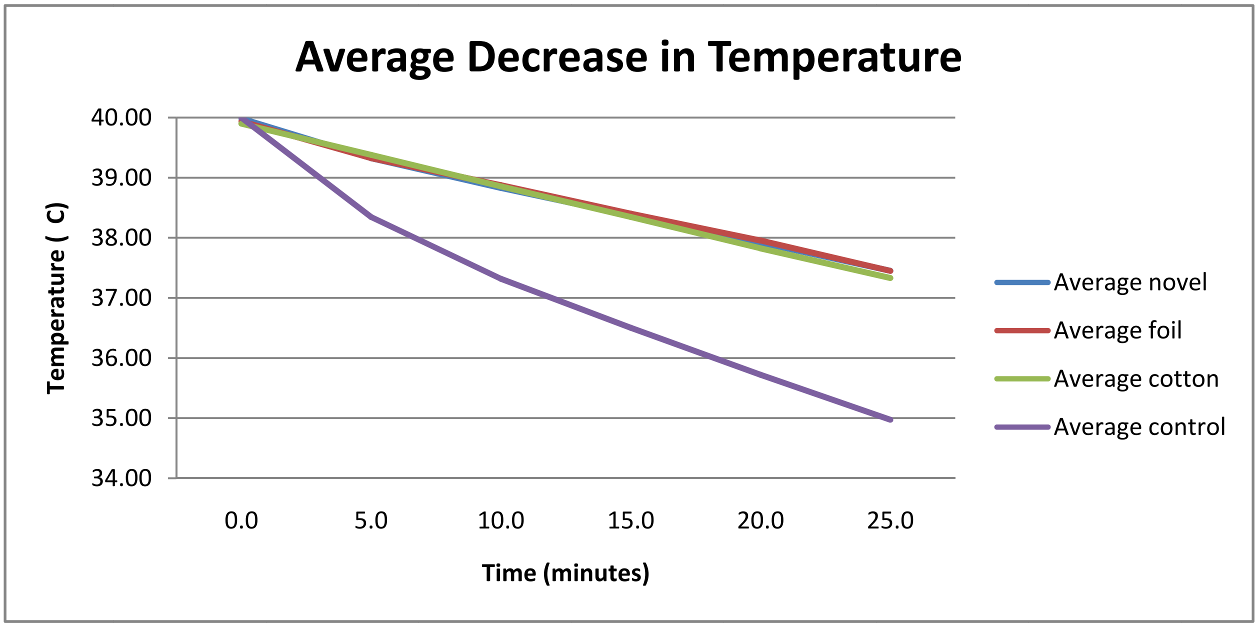

Figure 9 represents the drop in temperature over the duration of the test trials.

Figure 10

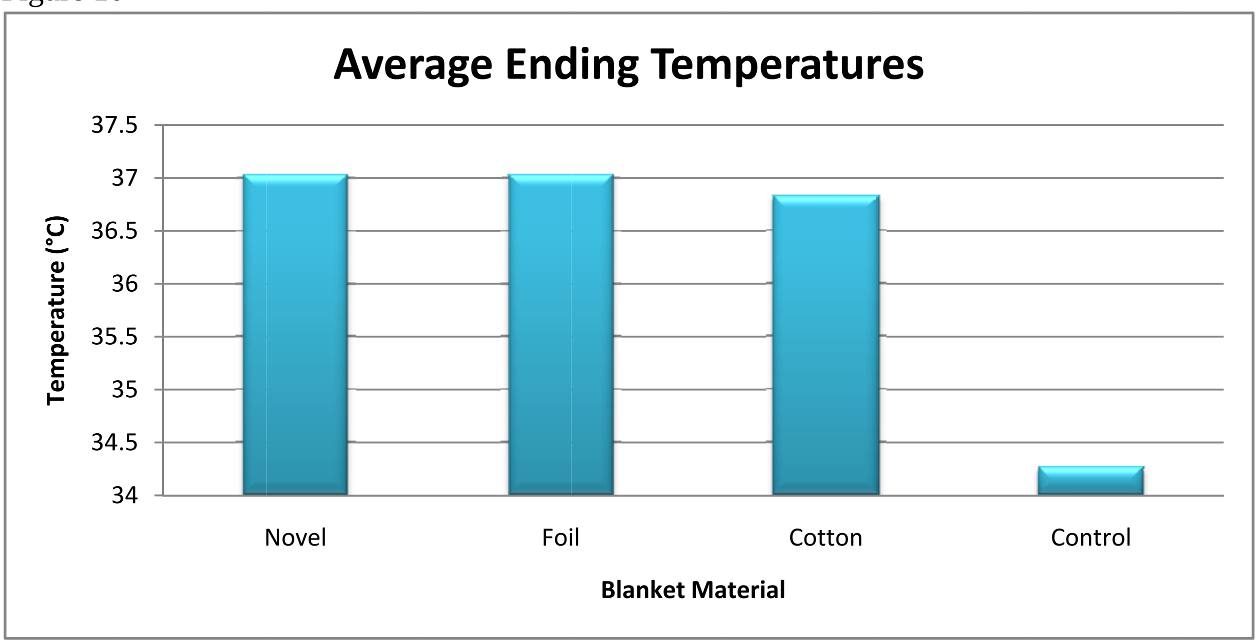

Figure 10 represents the ending temperature with the application of each blanket's material.

Figure 11

Figure 11 indicates the difference in the averages between the trials. The Sig. being less than 0.5 indicates a significant difference between tests.

Figure 12

Figure 12 indicates the differences in the averages between each of the trials and how they altered between blankets. The Sig. indicates a difference between trials.

Figure 13

Figure 13 indicates a representation of the results found by running a Tukey HSD test. Groups 1 and 2 show the statistical differences presented by the data. Group 1 indicates a difference for the control. Group 2 shows minimal differences between the cotton, novel, and mylar run tests.

Data Analysis

Overall the results indicated that using a blanket retained heat more efficiently. The cotton blanket lost more heat than the mylar and novel blanket, but there was little difference between the novel and mylar blanket in terms of heat loss. Nonetheless, the mylar and novel blankets lost less heat than the cotton blanket. The mylar and novel blankets' ending temperatures were very similar.

Conclusion

Overall the results demonstrated that the use of a blanket proved more effective than no blanket use at all. The mylar and novel blankets lost less heat than the cotton blanket, but there was minimal difference between the novel and mylar blanket in terms of heat loss. The mylar and novel blankets' also had very similar ending temperatures.

The results indicate that there was a significant change in temperature when the blankets were used; meaning heat was more efficiently retained. However, there was little variance between the blankets themselves. The Wilks Lambda test showed a significant difference between the groups. Greenhouse Geisser test confirmed that both sub factors, time and type are different. The Tukey test showed the difference between in recorded data between blankets. Nonetheless, the novel blanket design retained heat at an equal rate as the foil blanket. The cotton blanket retained less heat than both the foil and novel blankets. Ultimately, the downside is that the foil blankets do not permeate heat adequately, whereas the novel blanket provides ventilation that will allow the heat to get through.

The flaws in the procedure include various aspects that could have been done differently. It was an option to design various novel blankets to determine which one best retains heat, but also allows heat to be retained, and strive for that median between the cotton and foil blanket. The median would present a more efficient balance. The neonate's heat would be retained more efficiently than with the cotton blanket, and since there would be more ventilation, the heat would also have a greater means to escape, rather than like in the novel blanket used in the experiments, which had miniscule air pockets.

The blanket was also not tested on any infants. However, the fact that it was tested in the refrigerator, which allowed for greater temperature changes provided more efficient results.

Overall, SPPS software and the tests ran, the results were more distinguishable. The use of a blanket showed a drastic change in temperature changes, in reference to the control. Between blankets, the cotton blankets temperature change was relatively greater than the foil and novel blankets, but it did not show drastic statistical differences. The average of the temperature changes between the foil and novel blankets was minimal; there was barely a difference between their changes in temperature. Taking the temperature change into consideration, they indicated that there was a similarity to the foil blanket, and since there was an interweaving of the foil and cotton blanket, this would explain why the temperature change remained similar to the foil blanket.

Figure 14 - A newborn wrapped in a cotton blanket

Nevertheless, although the novel blanket did not reach the desire median of temperature change between the cotton and foil blankets, it did retain heat more efficiently than the cotton blanket. Further studies for the experiment would include running more trials to attain a broader set of results, and also experimenting with various designs. The possible designs that may prove efficient may include utilizing patches of the cotton and foil blankets, so that the foil patches would retain heat and the cotton patches would provide a means for the heat to escape.

Because the results of this experiment proved that blankets do make a difference, but the novel one did not differ greatly from the foil blanket, this indicates that in order for the project to be a success further research must be done. If this project were to be conducted again, the testing of various blanket designs would be attemped, and also possibly explore different materials. The blanket was made out of materials that would be cost-efficient, and also attainable. It might need an alteration of the design, such as the patches mentioned previously, or perhaps a different cotton blanket that did not revolve around the thermal use of the blanket and had a thicker material, which would also aid in the heat retention.

Figure 15 - A newborn in an incubator

Other materials that may be more effective for heat retention, but have not been tested during the duration of this project. Fleece may also be a good insulator. If there was time to conduct more experiments I would address various different aspects for the blanket, and possibly new methods to test them as well. The heat permeability of the blanket was also not tested, so there was no way of knowing how efficiently the blanket allowed heat to penetrate it. There was no means of knowing if an incubator would allow the heat to reach the baby. Therefore, it cannot be concluded that novel blanket more efficiently allow heat to permeate its surface. Nonetheless, the novel blanket did retain heat more so than the cotton blanket, and there for was successful to an extent.

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