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The Effect of the Warm Water Bath on Axillary Temperature in Normal Newborns

Ann J. Morton

Abstract

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The purpose of this study was to compare the effects of the warm water bath and the radiant heater on the axillary temperatures of normal newborns. The sample group consisted of thirty newborns--15 babies placed into the water bath in Group I, and 15 babies placed under the radiant heater in Group II. Birth weights were between 6.25 and 8.75 pounds, gestational ages between 37 and 41 weeks, and 5-minute Apgar scores were 8 or more. The maternal temperatures, taken within two hours before birth, ranged between 97 and 99 degrees. All infants were born by spontaneous or low-forceps vertex deliveries, and labor lasted between three and nineteen hours. The infants in Group I were placed in a 99-degree water bath as soon as the umbilical cord was clamped and cut and remained there for 10 minutes. The infants in Group II were placed underneath an overhead radiant heater set on "high" for 10 minutes as soon as the umbilical cord was clamped and cut. Axillary temperatures were taken for each subject at 15-minute intervals for two hours after birth. During these two hours, all infants remained with their parent(s) in the recovery area. The data comparing the effects of the two procedures on the infant's temperature stabilization time and two-hour temperature were analyzed using an analysis of covariance and partial correlation. The results of these analyses showed that the water bath

group had significantly shorter temperature stabilization times ($p=.001$), and also significantly higher two-hour temperatures ($p=0.05$). Maternal temperature and time interval between birth and warming also were found to have significant effects on temperature stabilization time and two-hour temperature. It was concluded that not only may the water bath be used without fear of adverse effects on the infant's temperature, but that for the 30 study subjects, the water bath is more effective than the radiant heater in stabilizing and increasing the infant's axillary temperature within the first two hours after birth.

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by

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INTRODUCTION AND STATEMENT OF THE PROBLEM

Introduction

> Thou Nurse in swaddling bands the Babe enfold
> And carefully defend its Limbs from Cold
> If Winter, by the Chimney place the Chair
> If Summer, then admit the cooling Air........
> Old Quatrain
> (Scopes, 1970, p. 31)

Man living in the modern world is essentially a tropical creature and seldom needs to become physiologically adapted to cold (Heim, 1971, p. 790). This is not the case, however, with his offspring. The air conditioned delivery room is designed for the gowned delivery personnel. It is not at all thermally suited for the naked, wet, newly born infant (Evans, 1974, p. 202). Birth is the universal cold stress for an infant in a civilized society. The extra energy demanded of a small infant who is cold may create enough added stress to kill him. It is "like forcing an older patient with heart failure and pulmonary edema to run a mile." (Miller, 1971, p. 47) Therefore it is imperative to conserve heat during the baby's first few hours of independent life, since both his survival and his chance of becoming a healthy child are markedly influenced by the temperature of his surrounding environment (Heim, 1971, p. 790).

Background

The earliest records of temperature regulation of the newborn infant are found in the Old Testament, where swaddling was used for both symbolic and practical purposes. The technic of swaddling used by the Greeks and Romans persisted throughout Europe into the Middle Ages. This practice disappeared from England and France in the latter part of the eighteenth century (Motil and Blackburn, 1973, p. 634).

The modern era of thermoregulation was ushered in during the 1890's by the physician Pierre-Constant Budin, who fabricated the concept of the environmental "cold stress" imposed on infants at birth. In an attempt to combat the effects of cold stress, Budin designed an incubator which provided for one-way flow of warm air, additional humidity and temperature monitoring of the environment (Motil and Blackburn, 1973, p. 635).

Since Budin's time, many advances have been made in the field of thermoregulation of the newborn. In 1961, Karl Bruck determined that the human infant is homothermic from birth, but that the thermal control mechanisms still need assistance in overcoming the stress encountered at birth (Bruck, 1961, p. 111). Modern mechanisms used to control the infant's environment include servocontrol mechanisms on overhead heaters, incubators, and heated mattresses, perspex heat shields, swaddlers made of plastic or aluminum foil, and others. Today, most hospitals use radiant heaters in the delivery room to warm the infant and his immediate environment (Korones, 1976, p. 72).

In 1975, Dr. Frederick Le Boyer, a French obstetrician, introduced his method of child delivery, "birth without violence." Le Boyer proposed the manipulation of several environmental factors in an attempt to simulate the intrauterine environment as closely as possible. The object of this manipulation was to decrease birth trauma caused by sensory shock. One of the procedures inherent in this method is to place the newborn baby in a 37 degree (Celsius) water bath after the cord is clamped and separated. The baby remains in the water bath as long as the parents desire; the mean time being between ten to fifteen minutes. When the baby is removed from the bath, he is dried and wrapped in a warm blanket and given to the mother and put to breast (Mahan, 1976, p. 52).

There has been considerable professional and personal interest in the Le Boyer method of delivery. Implementation of the procedure has occurred with seemingly very limited study done of the procedure's effects on the physiological responses in the newborn (Trotter, 1975, p. 107).

Statement of the Problem

Maintenance of an optimal thermal environment is one of the most important aspects of effective neonatal care (Korones, 1976, p. 64). To maintain safe practices in the delivery area, it is imperative that the delivery room personnel have information regarding the effect of the warm water bath on the baby's axillary temperature, as compared with the standard practice of using the radiant heater. Therefore, the statement of the problem for this study was: How do the axillary temperature readings of normal newborns placed in the warm water bath and under the radiant heater compare?

THEORETICAL DEVELOPMENT

Temperature stabilization in the newborn is achieved when balance is maintained between the amount of heat produced and the amount of heat lost (Heim, 1971, p. 805). The newborn's normal capacity for heat production is developed and is stimulated by the "cold stress" experienced at birth (Heim, 1971, p. 805). Thus, one would imagine that the infant could compensate for his cold stress by increased heat production. However, the anatomy of the newborn predisposes him to excessive amounts of heat loss through four avenues: conduction, convection, evaporation, and radiation (Korones, 1976, p. 65). This heat loss has been calculated as 200 cal/kg/min at birth, compared to a heat production capacity of 80 cal/kg/min (Scopes, 1970, p. 48). Thus, the birth experience creates a large discrepancy between rate of heat loss and rate of heat production, and the unattended newborn has no chance for thermal stabilization. Only when he is given aid through procedures that help decrease heat loss from these four avenues can temperature stability be obtained.

The radiant infant warmer provides an environment for the baby in which warm circulating air emanates from an overhead radiant source (Korones, 1976, p. 72). Since warm circulating air decreases conductive and convective heat loss and poorly conductive material on the mattress further decreases conductive heat loss, the radiant warmer should help provide an environment that will decrease both conductive and convective expenditures (Baum, 1968, p. 32). Also, the radiant heat that the warmer provides compensates for losses due to convection and evaporation (Adamsons, 1966, p. 612). Heat lost by a combination of conduction, convection, and evaporation make up approximately 33 per cent of the total heat loss (Smith, 1969, p. 644). Therefore, theoretically, the radiant heater encourages temperature stabilization by decreasing heat loss to the infant's environment by about one-third.

The warm water bath provides the infant an environment of a good conductive source of warmth at one hundred per cent absolute humidity. The wet newborn loses a significant amount of body heat through evaporation of amniotic fluid from his skin's surface (Motil and Blackburn, 1973, p. 635). This evaporative heat loss is inversely related to the absolute humidity of the environment (Hey, 1975, p. 71). Therefore, by placing the newborn in a fluid environment, evaporative heat loss should be virtually eliminated. Also, water has a twenty-five times greater thermal conductivity than air, so taking the baby from an environment of cold air and placing him in an environment of warm water should decrease conductive heat loss (Smith and Hanna, 1975, p. 100). Convective heat loss is also minimized in the warm water bath since about 80 per cent of the body surface is submerged, and thus unaffected by the cool air environment (Bruck, 1961, p. 70). Since evaporation accounts for about 25 per cent of total heat loss, conductive accounts for about 5 per cent, and convective heat loss is minimal (1%), placing the baby in a warm water bath should, theoretically, decrease heat loss by approximately 31 per cent (Motil and Blackburn, 1973, pp. 635-636).

DESIGN OF THE STUDY

Purpose of the Study

The purpose of this study was to improve nursing care of newborns by comparing the effects of the radiant heater and the warm water bath on axillary temperature. These results would assist in determining whether there is a difference in the effectiveness of the two methods in maintaining thermal control in the newborn.

Hypotheses of the Study

The two hypotheses for the study were: (1) there will be no significant difference (p=0.05) between the amount of time passing before temperature stabilization occurs in the two groups; and (2) there will be no significant difference (p=0.05) between the body temperatures of the two groups at the end of the two-hour testing period.

Definition of Terms

Body temperature. Body temperature was measured as axillary temperature, using a mercury thermometer left in place for three minutes.

Temperature stabilization. For this study, temperature stabilization was defined as three consecutive readings of 98 degrees or more, with the first of these readings determining the time at which temperature stabilization occurred.

Normal newborns. Normal newborns were those babies born by spontaneous or low forceps, vertex delivery, and labor lasting between three and 24 hours, with no apparent anomalies or signs of post-maturity, weighing between 5.5 and 10 pounds. They were 37 to 41 weeks old by gestational age, had a five-minute Apgar score of 7 or more, and were born of mothers having an oral temperature between 97 and 99 degrees within two hours before delivery.

Warm water bath. A tap water bath maintained at 99 degrees.

Radiant infant warmer. An open-table heater with an overhead radiant heat source, set on the "high" temperature setting.

Assumptions of the Study

It was assumed that allowing the parents to choose the group their child would be placed in would not jeopardize the results of this study, i.e., that no correlation existed between the parents' choice of groups and an effect on the infant's temperature. It was assumed that there was no significant difference in axillary temperatures due to differences in brown fat deposits among the research subjects, since they were all normal, term babies (Korones, 1976, p. 72). It was also assumed that all of the thermometer readings were equally accurate. Lastly, it was assumed that the temperature and humidity of the delivery and recovery areas did not fluctuate substantially during the data collection period.

Limitations of the Study

The subjects used in this study comprised a sample of convenience since they were limited to those patients available to the researcher at a selected university medical center during the early months of 1978 (Collier and Elam, 1961, p. 52). The results of the study were limited to the reliability and validity of the axillary temperature readings. Lack of funds and time available for the research also limited the feasibility of maintaining a constant temperature in the water bath, measuring subcutaneous fat deposits of the infants, and recording air currents, temperature, and humidity of the recovery rooms. The researcher was further limited by a lack of background and skill as a researcher, and by lack of complete control over the labor and delivery procedures.

SUMMARY

This study was done to evaluate the effect of the warm water bath on the newborn's body temperature. The following chapters include a review of related literature, a chapter on the methodology used for data collection, a presentation of the data with its analysis, and a summary including conclusions and recommendations for future research.

Chapter 2

REVIEW OF THE LITERATURE

The problem under study in this research was to determine how two different warming procedures compare in their effect on axillary temperature. The principles of body thermodynamics with consideration given to neonatal application, different methods of thermal control, and lastly, studies similar in some aspects to the one undertaken were evaluated for suggestions in methodology and data analysis.

BODY TEMPERATURE

Before studying temperature regulation in the neonate it is necessary to explore the basis of temperature regulation--body temperature.

Definition

Adamsons defined body temperature as a term used to describe the temperature deep inside the body which under normal conditions remains in a constant thermal state (Adamsons, 1966, p. 600). This "core" temperature remains within plus or minus one degree F., without variation except during illness (Guyton, 1976, p. 955), while the temperature of the peripheral parts of the body change according to existing needs (Adamsons, 1966, p. 600). Within this ± 1° variation is a regular diurnal fluctuation of 0.5° to 0.7° C. (Ganong, 1975, p. 169) that is established around the end of the first year of life (Smith, 1959, p. 218).

"Normal" Body Temperature

Guyton states that there is no single temperature value that can be considered normal, but that there is a normal temperature range from approximately 97 to 99 degrees, with rectal values about one degree F. greater than oral temperatures (Guyton, 1976, p. 955). Axillary temperatures are usually one degree F. lower than oral temperatures (Mash and Dickens, 1973, p. 59).

Selle found that in most children, the range is more variable and tends to be 0.5 to 1.0 degrees F. (0.3 to 0.6°C.) higher than corresponding regional temperatures of adults (Selle, 1952, p. 8). Research conducted by VanPumbrouck refuted the idea of the two-degree difference between rectal and axillary measurements in newborns (Van Pumbrouck, 1961, p. 60). A comparison of 100 three-minute axillary and rectal readings showed the rectal temperature of 98.6 versus an axillary temperature of 98.0 (Van Pumbrouck, 1961, p. 33). Gibson and Grayson also found little difference between rectal and axillary temperatures in working with newborns (Gibson, 1945, p. 479; Grayson, 1951, p. 1381). Studies have suggested that race (DuBois, 1936, p. 75) and sex (Nichols, 1966, p. 308) may affect temperature readings. Torrance discovered, however, that in working with newborns there was no significant difference in readings between sexes or races (Torrance, 1967, p. 46). Smith agreed that no temperature difference exists between sexes until sometimes after infancy (Smith, 1959, p. 148).

Methods for Determining Body Temperature

Smith and DuBois state that total body temperature cannot be determined from a single reading or even a "series of readings" from any one area of the body (Smith, 1969, p. 645; DuBois, 1948, p. 18). Guyton proposes that an "average" body temperature can be approximated for an adult by multiplying 0.7 times the internal temperature, and adding 0.3 times surface temperature (Guyton, 1976, p. 955). For practical purposes, there are three methods of measuring body temperature in the newborn: rectal, axillary, and skin.

Rectal. The rectal temperature is representative of the "core" temperature of the body and varies least with changes in the environment (Ganong, 1975, p. 169). Very precise positioning of the thermometer is necessary since varied positioning markedly influences rectal temperature readings (Selle, 1952, p. 6). Most hospitals recommend that the initial temperature of the infant after delivery be taken rectally so that the presence of an imperforate anus may be promptly detected (Moore, 1968, p. 94). Rectal thermometer insertion may cause perforation of the anus (Torrance, 1967, p. 3). Korones suggests that although rectal temperature is helpful, normal core temperature does not necessarily indicate "thermal balance" in a chilled environment (Korones, 1976, p. 72).

Axillary. Axillary temperature is easier to take and less traumatic for the infant during repeated measurements than rectal temperature (Torrance, 1967, p. 3). Axillary temperatures are usually taken on small premature infants for this reason (Mash and Dickens, 1973, p. 89). Korones states that axillary temperatures can occasionally be falsely high due to subajacent deposits of heated brown fat and because warmth is created between the baby's arm and body (Korones, 1976, p. 72). However, Van Puymbrouck, in her study involving 100 full-term normal infants, found that from a clinical point of view, the axillary measure appears to be as useful as the rectal measure (Van Puymbrouck, 1961, p. 60).

Skin. The skin temperature receptors of newborns have a dominant influence over the metabolism of the neonate. They are quite sensitive to small changes in the environment and act independently of inner body temperature controls (Sinclair, 1972, p. 147). Surface temperature is the important factor in evoking metabolic responses to cold, and if skin temperature drops, the baby is considered to be in a state of "cold stress." (Korones, 1976, p. 73) Skin temperatures average 3.6° to 9° F. (2-5°C.) lower than core temperature (Selle, 1952, p. 9). Mean skin temperature reading using six different sites of the body is the most theoretically sound temperature reading (Scopes, 1970, p. 45) though reliable skin temperature readings are difficult to obtain under normal conditions (Selle, 1952, p. 9). Scopes states that skin temperature of the exposed abdominal wall is convenient and is the most reliable form of temperature measurement yet identified (Scopes, 1970, p. 45). Silverman and Sinclair have proposed that skin temperature be used extensively in clinical practice due to its apparent value in neonatal thermal control (Silverman and Sinclair, 1966, p. 147).

AVENUES OF HEAT LOSS

In preparing an experimentally controlled environment, all factors influencing the problem under study must be researched. The effective environmental temperature of the neonate is not simply a measure of ambient air temperature, but also reflects the radiative, conductive, convective, and evaporative aspects of its thermal environment as well (Evans, 1974, p. 203). Each of these aspects will be considered separately below.

Radiative Heat Loss

Radiation is one of the main channels of heat loss (Ganong, 1975, p. 107). If body temperature is greater than the temperatures of surrounding objects, heat is radiated to the objects (Guyton, 1976, p. 956). Therefore, radiative heat loss occurs between the infant and any immediate surrounding objects of lesser temperature (Evans, 1974, p. 203). Loss by radiation travels in a straight line (DuBois, 1948, p. 15), and is a function of the temperatures of solid objects (Oliver, 1965, p. 766). Radiative heat exchange is influenced by four primary factors:

1. the radiative characteristics of the body
2. the radiation area involved
3. the surface temperature
4. the mean temperature of surrounding objects (Selle, 1952, p. 24).

These factors are drawn directly from Newton's Law of Cooling States (DuBois, 1936, p. 59). Loss through radiation increases with an increase in surface area (Parmalee, 1952, p. 44). When dealing with newborns, it is increased substantially when the baby remains uncovered (Smith, 1969, p. 648). Considerable loss to cool walls of incubators can occur even at high ambient temperatures (Adamsons, 1966, p. 612). Under normal conditions, radiative heat loss accounts for 66 per cent (Motil and Blackburn, 1973, p. 635) or about two-thirds of total heat loss (Smith, 1969, p. 644). Coupled with convection, it accounts for greater than twice the amount of loss by evaporation (Dahm and James, 1972, p. 511).

Conductive Heat Loss

Conductive heat transfer occurs between one molecule and another through solids, liquids, and gases by direct contact. Rate of the heat transfer depends on two factors:

1. the thermal conductivity of the substance
2. the difference between the temperatures of the two objects (Selle, 1952, p. 251).

Conductive loss occurs between the infant and cooler surrounding objects that he comes into direct contact with. The loss varies, but is usually less than 5 per cent of the total heat lost (Ganong, 1975, p. 170), and usually increases when only radiative forms of heat are used (Evans, 1974, p. 203).

Convective Heat Loss

Convection is a third main channel of heat loss. It is a form of heat transfer by currents of air and water and depends upon the following factors:

1. total surface area of the body
2. the difference between the body's average temperature and the air temperature
3. the rate of air flow (Selle, 1952, p. 25).

Heat loss by convection is dependent on the process of conduction. First, heat is conducted to the air, and then it is carried away by convective currents (Guyton, 1976, p. 957). Logically, convective losses rise proportionally with air movement (DuBois, 1948, p. 17). Also, convective transfer is much greater in water than air because of the higher specific heat of water (DuBois, 1936, p. 58). Unless a body is shielded from air currents, heat loss through convection can be substantial (Evans, 1974, p. 203). It has been clinically proven that protected from air currents, the baby loses only minimal heat through convection (Motil and Blackburn, 1973, p. 636).

Evaporative Heat Loss

Evaporation is a function of the relative humidity of the air (Oliver, 1965, p. 766). Every gram of water that evaporates from the skin absorbs about 0.58 kilocalories of heat from the skin (DuBois, 1948, p. 17). The average infant is covered at birth by at least 15 grams of amniotic fluid (Evans, 1974, p. 203). Therefore, about 8.655 calories of heat are lost as the fluid evaporates from the baby's skin (Evans, 1974, p. 203). During the first 30 minutes of life 19.1 calories/kilogram/minute are lost by evaporation (Dahm and James, 1972, p. 511). The total amount of evaporative loss depends on five factors:

1. the surface area
2. the amount of fluid present
3. the temperature of the skin
4. the humidity of the air
5. the velocity of air movement (Selle, 1952, p. 27).

Normally, evaporative loss accounts for 10 per cent (Adamsons, 1966, p. 612) to 25 per cent of total heat lost to the environment (Sinclair, 1972, p. 132). Evaporative loss increases substantially in less humid environments (Sinclair, 1972, p. 144).

In summary, the total amount of energy lost through the four avenues described above is contingent upon several other environmental variables: the temperature of the ambient air, its currents, the temperature of surrounding radiative surfaces, and the relative humidity of the air (Motil and Blackburn, 1973, p. 635).

THERMAL GRADIENTS

DuBois states that there is no one body temperature. Instead, he explains, each part of the body has its own temperature, thereby setting up a "series of gradients." (DuBois, 1948, p. 33) Heat is dissipated along a temperature gradient from the body core to the body surface, to the surrounding air (Sinclair, 1972, p. 135). This gradient is established as skin temperature falls, which eventually causes core temperature to decrease (Keay and Morgan, 1974, p. 67).

Body gradient is divided into two parts: internal and external. The "internal" gradient consists of that part of the gradient where heat flows from the core, internal organs of the body, across body tissues, to the cooler body surface (Heim, 1971, p. 791). The "external" gradient refers to the difference between skin temperature and environmental temperature (Heim, 1971, p. 791).

In 1965, Adamsons, when working with healthy, mature newborns 0 to 6 hours old, found that a temperature gradient of less than 1.5° C. correlated with minimal oxygen consumption (Adamsons, 1966, p. 610). The depth and degree of gradient depends on many factors, but especially the vasodilatative capacity of the body (DuBois, 1948, p. 31).

THERMOREGULATION IN THE NEWBORN

Body temperature stabilization is a product of elaborate thermoregulatory mechanisms. These mechanisms and some related concepts are discussed below.

Homothermy

Until several years ago, the human infant was considered to be a temporary poikilotherm. Selle, in 1952, said that small infants, especially prematures, were virtually poikilothermic, as did Silverman in 1958 (Scopes, 1970, p. 32). In 1961, however, Bruck discovered that homothermic responses were present at birth even in premature infants (Bruck, 1961, p. 111). This was confirmed in later studies such as those conducted by Hill and Rahimtulla in 1965, and by Scopes and Ahmed in 1966 (Scopes, 1970, p. 32). To explain the infant's seemingly poikilothermic intolerance to environmental changes, Bruck used the term "lack of practice" (Ungeubtheit) rather than "immaturity" of the infant's mechanism (Smith, 1959, p. 217). Parmalee stated that the newborn had some practice in preparing for the assumption of other new functions, but none for taking on heat regulation (Parmalee, 1952, p. 113). Vulliamy re-emphasizes again, however, that the regulatory mechanisms of reflex vasoconstriction and vasodilatation in the newborn occur from birth (Vulliamy, 1972, p. 53).

As a homotherm, the newborn attempts to control heat production and heat loss at a rate that will maintain a constant body temperature. The baby must do his best in using his available mechanisms to respond to adverse environmental conditions (Scopes, 1970, p. 32).

Thermal Stability

Adamsons defines thermal stability as being a property of an object that opposes temperature variation of central body tissues when heat exchange between the object and its environment is possible. "It is primarily a function of body size, surface area, thermal insulation and the degree by which heat output can be altered." For a certain body shape, temperature stability increases as body size increases (Adamsons, 1966, p. 600). Thermal stability is diminished in premature and dysmature infants (Heim, 1971, p. 800).

In newborns a stable rectal temperature is defined as being between 37 and 37.5 degrees C. (Evans, 1974, p. 204). Korones states that body temperature cannot vary over 0.3 per cent and remain stable (Korones, 1976, p. 64). Guyton adds that the core temperature is constant to within ± 1 degree F., as mentioned earlier (Guyton, 1976, p. 955).

Normal core temperature usually stabilizes in newborns within eight hours after birth unless warming procedures are instigated (Parmalee, 1952, p. 114; Oliver, 1965, p. 772). Motil and associates found that in infants placed in a 38 degree C. radiant warmer, over 75 per cent reached temperature stabilization within approximately two hours. In a 37 degree environment, almost 50 per cent reached temperature stabilization within the same amount of time (Motil, and Others, 1974, p. 548). Lambesis and associates also found that normal infants placed under an infra-red lamp reached axillary temperatures of 97 degrees within the first hour of life (Lambesis, and Others, 1976, p. 21).

Neutral Thermal Environment

The fetus lives in an environment which is practically constant (Parmalee, 1952, p. 173). Similarly, the aim in regulating a newborn's environment is to allow as little variation as possible once a neutral thermal environment is established (Vulliamy, 1972, p. 53). "Neutral thermal environment" is defined as that environment in which thermal conditions allow heat production to equal heat loss (Motil and Blackburn, 1973, p. 35). It is an environment where the baby maintains a normal temperature, a minimal metabolic rate, and a constant body temperature through vasomotor and sudomotor adjustment (Scopes, 1970, p. 32). The neutral environment includes a set of thermal conditions, including air temperature, and relative humidity at which heat production, measured as oxygen consumption, is minimal while "core" temperature remains normal (Oliver, 1965, p. 766).

For adults, neutral thermal temperature ranges from 26° to 31° C. (Oliver, 1965, p. 767). Bruck, Oliver, Karlberg and Silverman all agree that for term infants, 32° to 34° C. is "neutral air temperature." (Oliver, 1965, p. 767) The relative humidity of the air is another factor that influences the neutral environment. Most authors agree that a relative humidity of 50 per cent is necessary to maintain minimal metabolic activity (Heim, 1971, p. 790; Marlow, 1973, p. 132; Oliver, 1965, p. 767; Smith, 1969, p. 653).

Another way of determining neutral thermal environment is by looking at skin temperature. Silverman, Sinclair, and Agate, in 1966, found that the skin temperature of 36° to 36.5° C. was related with a minimum rate of oxygen consumption. They also found that even minor deviations to 35° or 37° C. greatly influenced metabolic rate (Scopes, 1970, p. 35). The researchers used a skin temperature reading over the region of the liver to determine this data (Smith, 1969, p. 648). They concluded that the measurement of body temperature, using skin temperature readings, is the only convenient way to assess whether the conditions of a neutral thermal environment are being met (Silverman and Sinclair, 1966, p. 147).

Thermoregulatory Mechanisms

The newborn infant has two lines of defense against adversely cold environments. He can work to prevent heat loss (thermotaxis), and he can work to produce extra heat (thermogenesis).

The principle ways in which the newborn can prevent added heat loss to his environment are through his body insulation (Moore, 1972, p. 76), by vasoconstriction, and by changing his posture to decrease exposed surface area (Adamsons, 1966, p. 608). The effect of peripheral vasoconstriction is to increase the core to skin temperature gradient, to increase insulation to its highest value (Sinclair, 1972, p. 139). Assuming the fetal position helps the newborn decrease his exposed surface area (Moore, 1972, p. 76).

The second way a baby can strive to control his thermal regulation is through heat production. When environmental temperature falls below the thermal neutral zone, heat production is stimulated proportional to the amount of "cold stress" applied (Sinclair, 1972, p. 139). As stated earlier in the literature review, deep body is not an essential stimulus for heat production in a cold environment (Heim, 1971, p. 794). Instead, heat production is evoked by skin receptor stimulation (Heim, 1971, p. 792). The subepithelial temperature sense organs respond to absolute temperature rather than the temperature gradient across the skin (Ganong, 1976, p. 76).

Guyton states that in the human adult, the liver, heart, brain and most of the endocrine glands produce most of the body heat (Guyton, 1976, p. 400). For additional heat production, adults rely on the shivering mechanism (Moore, 1972, p. 76). Therefore, the adult's skeletal muscles provide the source for additional heat production (Adamsons, 1966, p. 602).

Little is known about the final control mechanism of temperature regulation in the newborn (Bruck, 1961, p. 66), though Adamsons states that probably the same primary sites as in the adult produce the largest proportion of heat (Adamsons, 1966, p. 602). For increased heat production in unfavorable climates, newborns rely on both shivering and nonshivering thermogenesis (Korones, 1976, p. 76). In newborns, muscle tissue makes up approximately one-fourth of the total body mass (Adamsons, 1966, p. 602). Therefore, increased metabolic rate substantially increases heat production. Nonshivering mechanisms are metabolic processes by which oxygen consumption is increased independent of muscle activity (Motil and Blackburn, 1973, p. 636). The process by which it occurs is still not fully understood, though noradrenalin is thought to play a major role (Oliver, 1965, p. 770). Korones explains that the extra heat is produced as a by-product of accelerated chemical reactions that occur at the cellular level when the metabolic rate is increased due to noradrenaline stimulation (Korones, 1976, p. 66). Nonshivering thermogenesis is considered to be more effective and economical than shivering thermogenesis (Heim, 1971, p. 791).

Brown fat is thought to be the primary source of energy for nonshivering thermogenesis (Korones, 1976, p. 66). This type of fat is characterized by having rich blood vessel and nerve supplies (Adamsons, 1966, p. 603). In the human infant, it is located primarily in the interscapular region, axillae, perineal areas, and around large vessels in the chest (Adamsons and Towell, 1965, p. 542). It comprises 2 to 6 per cent of the newborn's body weight (Korones, 1976, p. 67). Smith suggests that this adipose tissue may serve as a thermogenic buffer for the newborn by warming blood as it moves centrally from the extremities (Oliver, 1965, p. 771). Bruck estimated that the maximum increase in heat output for infants is about 2.5 times that in the resting state (Sinclair, 1972, p. 139).

FACTORS IMPAIRING REGULATION

There are several factors which impair thermoregulation in the newborn. One set of factors involves anatomical properties of the infant and the other is factors involving phenomena outside of the newborn's anatomical realm.

Factors Involving Newborn Anatomy

Thermoregulation is impaired in the newborn mainly due to his unfavorable "surface/volume index," his thin layer of subcutaneous fat, and his body's high "thermal transition coefficient." (Bruck, 1961, p. 111)

The infant's body is less conserving of body heat than the adult's body largely because of its large surface area relative to total body weight (Scopes, 1970, p. 39). The body mass of the newborn may be only about 5 per cent of that of the adult, but the newborn's surface area is about 15 per cent of the adult's (Motil and Blackburn, 1973, p. 635). Specifically, a 2 kilogram infant has a total body surface area to body weight ratio of $0.78m^2/kg$, while a 75 kilogram adult has a ratio of only $0.025m^2/kg$ (Evans, 1974, p. 203). The increased curvature of the newborn's body also aids heat loss to his environment, through conduction and radiation (Adamsons, 1966, p. 606).

The neonate's minimal subcutaneous fat as compared to the adult also contributes to increased heat loss because of reduced insulation of core body temperature by the skin (Evans, 1974, p. 203). This decreased thickness of subcutaneous fat results in a higher thermal conductance of heat from the interior of the body to the skin (Adamsons, 1966, p. 606). As explained, thermal conductivity describes the difference between the core and skin temperatures. It is a function of the factors discussed above, including the surface area/body mass ratio, and insulation of the body tissues, plus a third factor of vasomotor control (Oliver, 1965, p. 766).

Bruck estimates that because of these factors, heat loss in the newborn per unit of body mass is about four times that of the adult (Bruck, 1961, p. 111). Adamsons agrees that the smaller the body size and thermal insulation, the narrower will be the range of environmental temperatures in which the baby can maintain thermoregulation (Adamsons, 1966, p. 601).

Factors Other Than Newborn Anatomy

Three main factors apart from those already mentioned can also affect the thermal stability of the newborn. These factors include acute hypoxia, drugs administered to the mother during labor or delivery, and maternal nutritional state (Adamsons, 1966, p. 614).

Animal studies first done in the late 1950's suggested that acute hypoxia interfered with the normal metabolic response to cold in the newborn (Adamsons, 1966, p. 614). In contrast, it was found that chronic hypoxia, and, thus, low PO_2 levels had no effect on thermoregulation (Adamsons, 1966, p. 615). In 1958, Burnard and Cross established that birth asphyxia does interfere substantially in human newborns. Twice as much heat was lost to the environment in the immediate postnatal period in the asphyxiated group as was lost in the control group (Adamsons, 1966, p. 615). Clinical evidence to support this claim is that in babies suffering from hyaline membrane disease, metabolic response to cold is severely limited (Korones, 1976, p. 67). Adamsons continued to say that not only does asphyxia decrease heat production, it also decreases heat loss through peripheral vasodilatation (Adamsons and Towell, 1965, p. 811). Therefore, hypoxia in a thermoneutral environment does not affect temperature regulation, but few infants are in a thermoneutral environment at birth. In newborn rabbits, heat production through use of brown adipose tissue was especially affected by hypoxia (Heim, 1971, p. 811).

Drugs given to a mother during labor and delivery may directly or indirectly affect the thermoregulatory ability of the newborn. Any placentally transmitted drug which stimulates cutaneous vasodilatation in the newborn will result in a drop in the infant's body temperature due to factors explained earlier (Motil and Blackburn, 1973, p. 635). Adamsons reviewed the effects of drugs on the newborn's regulatory mechanisms and determined that the following types of drugs have an adverse effect: hypnotics, analgesics, antipyretics, anesthetics, neuromuscular and automatic blocking agents (Adamsons, 1966, p. 615). Vasodilators, antihypertensive agents, and hormones have the same effects (Adamsons and Towell, 1965, p. 545). Heim suggests that drugs interfere with thermogenesis either in the central control system or in peripheral control mechanisms (Heim, 1971, p. 795). Drugs can change the body's perception of thermal conditions and may affect the hypothalmic interpretation of the environment (Adamsons and Towell, 1965, p. 545). Specific examples of the adverse effects of drugs on newborn thermal control include Hey's discussion on diazepam decreasing the normal cold response (Hey, 1975, p. 73), and Adamsons' account of how reserpine affects the heat dissipation controls of the neonate rather than the heat production controls (Adamsons, 1966, p. 615). Burnard and Cross studied the effects of meperidine given to mothers in labor and found that the 64 babies resulting from labor when meperidine was given had temperatures .8° to 1.0" C. lower than the 53 babies in the control group. The temperatures of the babies in the meperidine group were still affected 20 hours after birth (Adamsons and Towell, 1965, p. 545).

A poor maternal nutritional state affects thermoregulation in the newborn in two ways. First, the central nervous system thermal control center is affected, and second, peripheral thermogenesis is affected by decreased substrate available as a source of heat production (Heim, 1971, p. 816). Besides the reduction in subcutaneous fat layers, hypoglycemia can occur due to poor maternal nutrition. This can add to the decreased output of thermal energy and the loss of body heat due to the greater conductivity of superficial tissues (Adamsons and Towell, 1965, p. 544).

Other, less frequent factors that impair metabolic response of the newborn to cold include intracranial hemorrhage, severe cerebral malformations (Korones, 1976, p. 67), and hypotension (Adamsons, 1966, p. 614).

THERMAL ENVIRONMENT AT BIRTH

At delivery, the deep body "core" temperature of the newborn is about 0.5° C. and skin temperature is about 2.5° C. higher than the mother's "core" temperature (Adamsons, 1966, p. 605). Suddenly, the baby is brought into a delivery room, cooled to suit the gowned delivery team. The newborn's capacity for heat production is quickly overtaken by liability to heat loss of "cold stress." (Keay and Morgan, 1974, p. 67) In the initial minutes following parturition, the rate of fall in body temperature of the newborn is dramatic. Adamsons explains that the rate of fall of deep body temperature and skin temperature is about 0.1° C/minute and 0.3° C/minute respectively. She states that this represents a heat loss of 200 calories/kilogram/minute assuming that 50 per cent of the newborn's body mass is at deep body temperature and the rest is at skin temperature (Adamsons and Towell, 1965, p. 531).

Some authorities have suggested that the "cold stress" experienced at birth is an essential element in the stimulation of the newborn's regulatory mechanisms. Scopes states that it is obvious from looking at animal studies that one of the stimuli to respiration is cold air on the newborn's face (Scopes, 1970, p. 46). Mestyan and coworkers found that changes in facial temperature alone are sufficient to modify total body oxygen consumption (Adamsons, 1966, p. 611). Dahm and James investigated this problem in response to Karlberg's findings that human infants delivered by Cesarean section and immediately placed in a warm bath may cease to breathe (Dahm and James, 1972, p. 504). They concluded that the reduction of cold stress by placing the newborn under a radiant heater immediately after birth did not "impede or delay" the onset of breathing (Dahm and James, 1972, p. 512).

STANDARD WARMING TECHNIQUES

The thermal environment of the infant is affected by air temperature, temperature of radiative and conductive surfaces, relative humidity, and rate of air flow (Scopes, 1970, p. 44). Thermal care of the infant after birth involves helping his homothermic mechanisms cope by decreasing avenues of heat loss. The basic means of preventing heat loss to the environment include drying the baby, clothing him, and placing him in a controlled thermal environment (Keay and Morgan, 1974, p. 440).

Drying and Clothing the Newborn

Dahm and James found that merely drying infants in the delivery room reduced heat loss by 19.1 calories/kilogram/minute. They also found that wrapping the babies in blankets decreased heat loss from radiation and convection by 42.4 calories/kilogram/minute (Dahm and James, 1972, p. 511). Sinclair adds that the addition of clothing provides enough increased insulation to permit a newborn to withstand significantly lower environmental temperatures (Sinclair, 1972, p. 138). Scopes states that the clothed baby in a regular cot is safer thermally than the naked baby in a controlled-environment incubator (Scopes, 1970, p. 46). Vulliamy stresses that unnecessary exposure must be avoided at all costs (Vulliamy, 1972, p. 53). Baum includes the importance of using a head covering to decrease convective heat loss (Baum, 1968, p. 32). This is based on the fact that the head constitutes between 9 and 18 per cent of the newborn's total body surface (Miller, 1971, p. 47).

Controlled Thermal Environment

Because of the adverse environmental conditions present at birth, Evans suggests that the newborn infant be placed in a controlled thermal environment within one minute after delivery (Evans, 1974, p. 204). Baum states that an environment geared at controlling heat loss consists of warm circulating air at high humidity, where the infant is surrounded by materials with poor conductive and radiative properties (Baum, 1968, p. 32). Evans suggests that the ideal environment consists of a servocontrolled radiant heater with an isothermic (37.5° C.) circulating water mattress (Evans, 1974, p. 205). Other suggestions for decreased radiative heat loss include using a transparent perspex heat shield (Scopes, 1970, p. 34), or a plastic (Miller, 1971, p. 47) or aluminum foil swaddler (Keay and Morgan, 1974, p. 440). Heated environments are provided with overhead heaters, incubators (Marlow, 1973, p. 133), heated mattresses, and other devices using servocontrol mechanisms (Keay and Morgan, 1974, p. 440). Evans insists that only overhead radiant heaters provide a neutral thermal environment while also permitting complete access to infants, who may need resuscitation (Evans, 1974, p. 207).

In 1900, Budin recommended warm baths at 37° C. to rewarm babies experiencing cold stress at birth (Dawes, 1974, p. 55). Today, there is uncertainty as to whether the warm bath is safe for use soon after delivery. Vulliamy suggests that the first bath is probably best given right after the umbilical cord is cut (Vulliamy, 1972, p. 55). As stated in the first chapter, warm water baths are also being given as a part of the "gentle birth" technique proposed by Dr. LeBoyer. DuBois has stated that between 36° and 37° C., at 100 per cent humidity, there is no body heat loss (DuBois, 1936, p. 61). Motil and Blackburn insist that the practice of bathing the infant in the delivery room is to be discouraged (Motil and Blackburn, 1973, p. 637).

RELATED STUDIES

Several studies found in the review of literature had specific parallels to this research. Each study compared the effects of different environments on body temperature in the newborn. Although these studies did not exactly parallel the author's study, knowledge about methodology and analysis of data could be derived from them. Five such studies are summarized below.

Dahm and James conducted a study in 1972 at Columbia University. They undertook to determine whether initial heat loss to a neonate's environment was primarily through evaporation, and whether the establishment of breathing would be hampered by reduction of cold stress at birth. They used five environmental conditions, having ten subjects assigned to each. The groups were divided according to the following criteria:

Group 1--infants undried, placed on dry sheet at room temperature
Group 2--infants dried, placed on dry sheet at room temperature

Group 3--infants dried, wrapped in warmed blanket with only small amount of face exposed
Group 4--infants undried, placed on warmed sheet under radiant heater
Group 5--infants dried, placed on warmed sheet under radiant heater

Skin temperature was maintained under the radiant heater at 37° C. Abdominal skin temperatures and rectal temperatures were taken at birth and every five minutes afterwards for thirty minutes. Factors analyzed included the relationship between the amount of analgesia used and body temperatures, and a comparison of group temperatures according to body weight. They also compared the mean body temperatures and amount of variability of the group temperatures. Maternal temperature was recorded for each subject, as well as weight at birth, and gestational age. The results of this study have been reported in previous sections of the literature review.

At the Ohio State University College of Medicine, Miller and Oliver, in 1966, also compared different post-delivery environments and their effects on newborn temperature. They used 37 healthy, term infants divided into three groups. The first group received routine delivery care plus a bath upon admission to the nursery. The second group received only routine delivery care. The third group received prompt drying and placement in incubators with air temperatures between 32° and 33° C. Rectal and skin temperatures were taken at birth and every five minutes for the first hour, followed by every 15 minutes for the next seven hours. Factors measured in their investigation included the air temperatures and relative humidity of the delivery room and nursery. Babies' weight, gestational age, and Apgar scores were also recorded. They found that the babies who were dried and placed in the incubator reached normal core temperature within three hours, and had higher temperatures than babies in the other groups. The babies who were bathed in the nursery showed the greatest temperature drop.

In 1974, Motil, Blackburn and Pleasure conducted a study at the Medical College of Pennsylvania, in which the effects of four different radiant warmer temperature settings were compared. Forty-two normal, term infants were used in the study. They were grouped according to their deep rectal temperature upon admission to the study, than randomly assigned to one of the four temperature groups: 35°, 36°, 37°, and 38° C. Rectal temperature, skin temperature, heart rate, respiratory rate, and activity were recorded at ten-minute intervals for four hours. Factors included in data recording included gestational age, weight and Apgar scores for each subject. Mean rectal temperatures were compared for each group at 20-minute intervals. Analysis of the data included the mean, standard deviation, and significance of trend for each group. The study concluded that the 38° C. group achieved normal rectal temperatures sooner than the other groups, without evidence of ill effects.

Hey and O'Connell conducted a study in 1970 at the London Hospital Medical College. In their study, 42 clothed babies were placed under varied environmental conditions to determine the effect on oxygen consumption and heat balance. Both premature and full-term babies were used. Each baby was studied in six different temperature environments over a period of two days. Measurements were obtained for 20 minutes at each different temperature. Air speed and humidity of each environment were observed and recorded. The results stated that clothing substantially increased the total insulation and minimized the effect of fluctuations in environmental temperatrues on heat loss.

Lastly, in 1976, Lambesis and associates conducted an unpublished study at the University of Illinois Medical Center. An experimental approach was used in studying two groups of eight normal, term babies. The control group babies remained under the infra-red lamp until axillary temperature of at least 97° F. was reached, then they were dressed and covered and placed in a plastic bassinet. The babies in the experimental group were placed under the infra-red lamp only while being admitted to the nursery. Once admitted, they were dressed and were given continuous close body contact by being held in the researcher's arms, against the body, for the remainder of the study period. Axillary temperature recordings were taken at the time of admission into the study, and every 30 minutes for four hours. Gestational age, weight of the baby, Apgar scores and length of labor were among the factors measured and recorded. Stable temperature was defined as 97° F. axillary measurement. The results of the study showed no significant difference between the mean body temperatures of the two groups during the timed experiment, though the experimental group showed less variation in temperature readings.

SUMMARY

Authors agree that there is no one set point defined as "normal" body temperature, though specific measurements have been proposed for practical application. Three different methods are used to measure body temperature in the newborn, each with its advantages and disadvantages. Authors disagree as to the most appropriate form of temperature measurement for newborns. The infant loses heat by four avenues through thermal gradients of his body. He strives to stabilize his body temperature and limits have been defined for an environment that would facilitate this task. However, certain factors impair thermal stabilization in the neonate. Several different methods are being used to externally help the infant maintain a stable body temperature and studies have been done to compare some of these methods.

Chapter 3

METHOD OF APPROACH AND DATA COLLECTION

METHODOLOGY

A comparative, quasi-experimental approach was used for this study. The research incorporated independent group design, involving two parallel groups, matched according to the characteristics considered essential for this study. Temperature readings were collected for each group for static-group comparison and analysis. The radiant warmer infants comprised the non-randomized control group.

According to Fox, the experimental approach involves a new method or technique and a basis for evaluating its effectiveness. The experiment is designed so that any differences between the groups involved can be directly attributed to the independent variable (Fox, 1976, p. 195). This implies total control or elimination of any extraneous variables.

The quasi-experimental approach includes the same principles as the experimental approach, but differs in its ability to control extraneous variables. All feasible variables are controlled and variables that cannot be manipulated are listed as limitations of the study (Campbell and Stanley, 1966, p. 34). Independent groups design involves two groups of subjects, one being the control group. Two groups are said to be parallel when their essential characteristics are matched (Campbell and Stanley, 1966, p. 6).

Static-group comparison involves two groups of subjects. One group's treatment is manipulated, causing it to become the experimental group. The other group receives routine treatment; thus, it is the control group. Following the experimental manipulation, the two groups are compared and their differences are evaluated (Campbell and Stanley, 1966, p. 12).

Development of the Research Tools

Demographic data chart. As mentioned, certain characteristics were identified through literature review as having definitive effects on thermal regulation in the newborn. Characteristics concerning the demographic data, including sex, duration of labor, gestational age, mother's temperature, certain delivery information, weight, length, surface area, five-minute Apgar score, and time interval between birth and warming were recorded for each subject on the Demographic Data charts (Appendix I). Surface area was computed using a nomogram for estimating surface area (Appendix H) (Brunner and Suddarth, 1974, p. 1428).

Data collection form. The researcher developed the data collection form (Appendix E) to facilitate accurate data collection and compilation. The information recorded on the form included demographic data, controlled variable data, time interval between birth and warming, and a record of the subject's axillary temperature readings at 15-minute intervals.

Setting of the Study

The facilities of the labor and delivery unit at a selected university medical center were used for the collection of data. The university medical center was a 516-bed facility serving the Southern California area. Permission was obtained from both medical and nursing personnel involved in the research area before data collection began (see Appendices A and B).

Criterion for Selection of Subjects

The subjects of this study were selected according to criteria defining normal, term neonates. Factors involving the labor and delivery process, as well as demographic characteristics of the mother were accounted for in this definition.

Normal newborns are born from uncomplicated labor and delivery. Therefore, only babies born in the vertex position by either spontaneous or low-forceps delivery were accepted for this study (Nelson, 1975, p. 328). Also, labor lasting less than three hours or more than 24 hours was considered abnormal, and these babies were not accepted as subjects (Oxorn and Foote, 1975, p. 101). Duration of labor was based on the patient's account of when regular contractions began. Babies born of diabetic or toxemic mothers were also not considered in the study (Nelson, 1975, p. 337).

Normal labor and delivery may involve the administration of certain drugs for pain management. The medications considered acceptable for use during labor included narcotics, tranquilizers, antiemetics, and regional anesthesias. Dosage for these drugs was not regulated, based on the assumption that any dosage large enough to depress the infant would exclude the infant from the study due to the Apgar rating criteria mentioned later in this section. Babies born of mothers receiving oxytocins, general anesthesia, or any other drugs not given during normal labor and delivery were excluded from the study (Fitzpatrick, 1971, p. 228).

The mother's temperature is an index of the fetus' thermal situation. Specifically, the body temperature of the fetus has generally been found to be 0.5° C. higher than that of the mother (Heim, 1971, p. 792). Thus, by observing the mother's temperature, infants with abnormally high or low temperatures could be eliminated from the study. Each mother's temperature was taken orally within two hours before delivery. A range of 97 to 99 maternal oral temperature was accepted as normal (Guyton, 1976, p. 955).

Another factor defining "normal" newborns was a five-minute Apgar score of 7 or more, since a 7 to 10 score indicates a healthy, non-stressed infant (Korones, 1976, p. 53). Criteria for selection of subjects also specified no visible anomalies of the baby, based on the obstetrician's examination of the baby at birth.

Term newborns were defined as being between 37 and 41 weeks old by gestational age (Cook, 1973, p. 64). Gestational age was determined by EDC dates and b-scans, if done, during the prenatal period. Babies accepted for the study also weighed between 5.5 and 10 pounds, since these are considered to be the parameters for normal newborn weight (Nelson, 1975, p. 19). Age and weight criteria were included since thermal stability is diminished in premature and dysmature infants (Marlow, 1973, p. 112; Heim, 1971, p. 800).

Method of Obtaining Consent

Each obstetrician at Loma Linda University Medical Center was asked prior to any data collection whether he would allow his patients to participate in the study. Once his approval was obtained, each of his patients was approached either in the clinic during prenatal appointments, or when they were admitted into the labor and delivery unit. Medi-Cal and clinic patients were also approached to be in the study. During this encounter, a thorough explanation of the study was given to each woman, through use of the "Information for the Parent" handout (Appendix G). Women agreeing to be in the study signed a consent form (Appendix F), knowing that they could drop out of the study at any time they wished.

For those women seen in the clinic, a list of the names of consenting women was given to the labor and delivery personnel, along with a note requesting to be notified when these women were admitted in labor. All other subjects were obtained through the researcher's placement of a note on the labor and delivery blackboard requesting to be called whenever any patient meeting the study criteria was admitted to the labor and delivery unit.

After each woman was admitted to labor and delivery, the researcher verified the woman's intent to be in the study, and placed the baby into one of the two study groups as specified by the parent(s).

DATA COLLECTION

Two groups of normal infants, as defined under the criteria for selection, were used in this study. After placement in one of the two groups, the subjects were treated as described below.

Each subject in the water bath group was placed in a 99 degree water bath as soon as the umbilical cord was clamped and cut. The baby remained in the bath for exactly 10 minutes, then was dried off, weighed, measured for length, wrapped in warmed blankets, and given to the mother to hold.

Each subject in the second group was dried off and placed under the radiant warmer after the umbilical cord was clamped and cut. The baby remained under the heater for exactly 10 minutes, then was weighed, measured for length, wrapped in a warmed blanket and given to the mother to hold.

Both groups of babies remained with their parent(s) in the recovery area for the remainder of the two-hour study period. During this time, the baby was not unwrapped and remained in constant close body contact with either the parent or researcher. Axillary temperature readings were recorded for each subject at 15-minute intervals, beginning 15 minutes after birth. The readings were obtained by the use of a mercury thermometer left in place for three minutes (Van Puymbrouck, 1961, p. 56).

The researcher endeavored to maintain control over certain variables by personally controlling the water bath temperature and the radiant warmer setting, and by placing the babies in the bath, to insure consistency of body surface below the water. She also helped control body heat loss by having the parent(s) refrain from unwrapping their babies in the recovery area. Maintenance of constant body contact during the recovery period also helped to equalize exposure to radiant body heat.

Tight controls were not placed on certain factors due to the purpose of the study. For instance, to experimentally compare the effects of the radiant heater to those of the water bath, the water would have to be monitored and kept at a constant temperature, as is the air under the radiant heater. However, since in practice the water bath is not constantly warmed, the researcher did not include this control in the study. Thus, the true effect of the water bath as it is currently being used could be clinically evaluated. Also, the "exactness" of body temperature reading was not necessary. Instead, a convenient method of temperature measurement was used in order to compare the readings of the two methods. That is why axillary temperature, rather than a more precise reading such as mean body temperature, was used for data gathering purposes.

TREATMENT OF THE DATA

A general linear model was used for the statistical analysis of co-variance of the data. This model was chosen over the use of the "t" test in order to compare the temperature stabilization times and the two-hour temperatures of the two groups after adjusting for extraneous variable influence (Dixon, 1969, p. 543).

PILOT STUDY

A pilot study was conducted, using two subjects for each of the groups, in order to judge the feasibility of the methodology. Several small changes in methodology resulted due to this trial application. First, a 15-minute warming period was found to be too long, and a 10-minute period was substituted. Second, a random assignment to the study groups proved unsatisfactory to the four parents in the pilot study. Therefore, the randomness of the grouping was discontinued, based on the assumption that the parents' choice of groups could in no way affect the infant's temperature readings. The third change in methodology developing from the pilot study dealt with the temperature readings. Obtaining an initial temperature reading at birth proved to be impractical. Therefore, the first temperature recording was taken at 15 minutes after birth.

Chapter 4

PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

The purpose of this study was to compare the effects of the warm water bath and the radiant heater on axillary temperature readings in normal newborns. This comparison was based on eight temperature recordings for each of 30 subjects, taken at 15-minute intervals for two hours after birth.

PRESENTATION OF DATA

Thirty normal newborns were involved in this study. They were divided equally between the two study groups.

Sex

Thirteen males and 17 females participated in this study. The water bath (WB) group contained eight males and seven females, while the radiant heater (RH) group contained five males and ten females.

Duration of Labor

The criteria established for this study regarding duration of labor included labor lasting between 3 and 24 hours. The actual range shown by subjects in the study extended from 3 to 19 hours. The WB group ranged from 3 to 14 hours, with a mean labor duration of 8.73 hours. The RH group subjects showed a slightly longer labor ranging from 4 to 19 hours, with 8.95 hours as its average.

Gestational Age

A gestational age of 37 to 41 weeks was defined for this study. Babies in the study ranged from 37 to 41 weeks. Mean gestational age for the entire sample was determined to be 39.4 weeks. The RH group displayed a gestational age .8 weeks longer than the WB group (Table 1).

Maternal Temperature

As stated earlier, the mother's temperature is considered an index of the fetus' thermal situation, and thus, of the newborn's temperature. A range of 97 to 99 oral temperatures was accepted as normal for maternal temperature (MT). The mean MT taken within two hours before birth for both groups combined was 98.1 degrees. The mean MT's of the two study groups varied only .2 degrees, with the RH group having the higher average reading (Table 2).

Uncomplicated Labor and Delivery

The subjects in this study were all delivered in the vertex position. Twenty-one of the subjects were born spontaneously. Eleven of these were WB babies, and 10 were subjects of the RH group. Four of the WB babies and five of the RH babies were delivered by low forceps extraction.

All mothers of the subjects received local, pudendal, or epidural anesthesia for delivery. Seven WB mothers and eight RH mothers were given local anesthesia. Two WB mothers and two RH mothers received pudendal anesthesia and epidural anesthesia was given to six WB mothers and five RH mothers.

Table 1

Distribution of Subjects by Gestational Age
and by Study Group

Gestational Age	WB	RH	Total
37 weeks	1	0	1
38 weeks	5	4	9
39 weeks	3	0	3
40 weeks	5	6	11
41 weeks	1	5	6
mean	39	39.8	39.4

Table 2

Distribution of Subjects by Maternal Temperature
and by Study Group

MT Range	WB	RH	Total
97.0-97.4	5	3	8
97.5-97.9	0	3	3
98.0-98.4	4	3	7
98.5-99.0	6	6	12
mean	98.0	98.2	98.1

Weight, Length and Surface Area/Weight

The weight of a "normal" newborn was defined as being between 5.5 pounds and 10 pounds. Babies in this study ranged between 6.25 pounds and 8.75 pounds. The mean weight for the entire study population was 7.69 pounds. The WB group mean weight was .31 pounds more than the mean weight for the RH group.

The subjects ranged between 18.75 and 22.25 inches long. Mean length for both groups combined was 20 inches.

Surface area was determined for each subject using a nomogram (Appendix H). Simple surface area measurements were not used for analysis because the literature emphasized the importance of the surface area per weight ratio (Sa/Wt). Therefore, the Sa/Wt ratio was computed for each subject in the study. The mean ratio for each group, as well as for the entire population of the study, was .028 square meters per pound of body weight (see Appendix I) (Table 3).

Apgar Scores

A five-minute Apgar of 7 or more was used as another criteria for defining a "normal" newborn. The two groups were fairly evenly matched for five-minute Apgar scores. One RH baby had an Apgar score of 8. Twelve RH babies and 13 WB babies rated a 9 at five minutes. Scores of 10 were given to two WB babies and two RH babies. The mean five-minute Apgar score for the WB group was 9.13, as compared to a 9.06 for the RH group.

Time Interval Between Birth and Warming

The time each infant was born was recorded, as well as the time

Table 3

Distribution of Subjects by Surface Area per Pound and by Study Group

Surface Area Per Pound of Body Weight (Square Meters)	WB	RH	Total
.026	2	1	3
.027	2	4	6
.028	4	5	9
.029	7	2	9
.030	0	3	3
mean	.028	.028	.028

at which warming began. The interval of time between these two recordings constituted the time interval (TI) between birth and warming. The TI for this study ranged from 1 to 6 minutes, with a mean TI for the entire study population of 2.86 minutes (rounded to 3 minutes for analytical purposes). The RH group had a mean TI of 1.47 minutes less than the mean WB group TI (Table 4).

Temperature

Axillary temperature readings were recorded for each subject at 15-minute intervals for two hours after birth (see Appendix J). From this information, it was observed that the initial temperature readings for all subjects ranged from 96 to 99.2 degrees, and final (2-hour) temperatures ranged from 97.6 to 99.6 degrees. Mean 2-hour temperature for all subjects was 98.85, used for analysis as 98.9 degrees. The WB group displayed higher initial and final mean temperatures than the RH group. However, of the two groups, the RH group showed a .93 degree larger increase in temperature between its mean initial and 2-hour temperatures (Table 5).

ANALYSIS AND INTERPRETATION

The three variables of maternal temperature, surface area per weight ratio and time interval were recognized as the main criteria which could be expected to affect the infant's temperature. In this study, these criteria were recognized as extraneous variables, and were recorded for each subject.

The data compiled for this study was analyzed for the purpose of

Table 4

Distribution of Subjects by Time Interval and by Study Group

Time Interval	WB	RH	Total
1 minute	0	8	8
2 minutes	3	1	4
3 minutes	5	3	8
4 minutes	4	2	6
5 minutes	1	1	2
6 minutes	2	0	2
mean	3.6	2.13	2.86

Table 5

Distribution of Subjects by Infant Temperatures and by Study Group

Initial Temperature			Final Temperature		
	Range	Mean		Range	Mean
WB	97.4-99.2	98.2	WB	97.8-99.6	98.88
RH	96.0-98.6	97.2	RH	97.6-99.6	98.81
Both	96.0-99.2	97.7	Both	97.6-99.6	98.85

comparing the effect of the RH and WB environments on the newborn's body temperature. Two stated hypotheses provided the basis on which the data could be evaluated. In the analysis of factoral influence on infant temperature, it was considered important to include an analysis of correlation of the other variables mentioned above, in addition to the WB versus RH comparison.

Hypothesis I--Primary Analysis

The first hypothesis for this study was: There will be no significant difference (p=0.05) between the amount of time passing before temperature stabilization occurs in the two groups. Temperature stabilization was defined as three consecutive readings of 98 degrees or more, with the first of such readings determining the time stabilization occurred. According to these criteria, the time interval at which stabilization occurred for each subject was recorded and tallied. The mean, median, standard deviation, and average deviation for stabilizing time (for those subjects that stabilized within the study period) were derived for each group (Tables 6 and 7). Two WB and three RH subjects did not stabilize within the 2-hour study period.

In order to analyze the true relationship between the design variables (the two study groups, WB and RH) and the dependent variable (TST) without extraneous variable influence, it was necessary to use a general linear model of analysis of covariance. For this test, an "F" value >4.24 represented significance at the 0.05 level, and an "F" value <7.77 was significant at the .001 level. Table 8 shows the "F" value for this analysis. This value demonstrated that the water bath group had a

Table 6

Distribution of Subjects by Temperature Stabilization Time and by Study Group

Group	Time Stabilization Occurred (Minutes)								
	15	30	45	60	75	90	105	120	> 2 hours
WB	8	0	5	0	0	0	0	0	2
RH	3	2	3	2	2	0	0	0	3

Table 7

Temperature Stabilization Time Criteria for the Two Study Groups

	Mean Time	Median Time	SD	AD
WB	26.5	15	15.19	11.53
RH	42.5	45	22.00	17.50
Total	34.2	30	---	---

Table 8

Statistical Analysis--Analysis of Variance (F Test)

Study Groups	Comparison	F Value	L.S.
WB and RH	TST	9.25	.001
	2HT	5.55	0.05

significantly shorter TST (p=.001). Therefore, the first hypothesis was rejected.

In addition to looking at the amount of time needed for each subject and group to stabilize, it was interesting to note how many subjects in each group, and what percentage, stabilized within the 2-hour period (Table 9, Figure 1).

Hypothesis I--Secondary Analysis

To be sure that the difference in stabilization times between the two groups was due solely to the variable of the warming environment, it was necessary to look at the amount of correlation between other variables and time taken to stabilize. If a correlation was found, it was then necessary to determine whether the variable identified with the correlation was equally distributed between the WB and RH groups, to rule out the possibility of this extraneous variable affecting the preceding analysis.

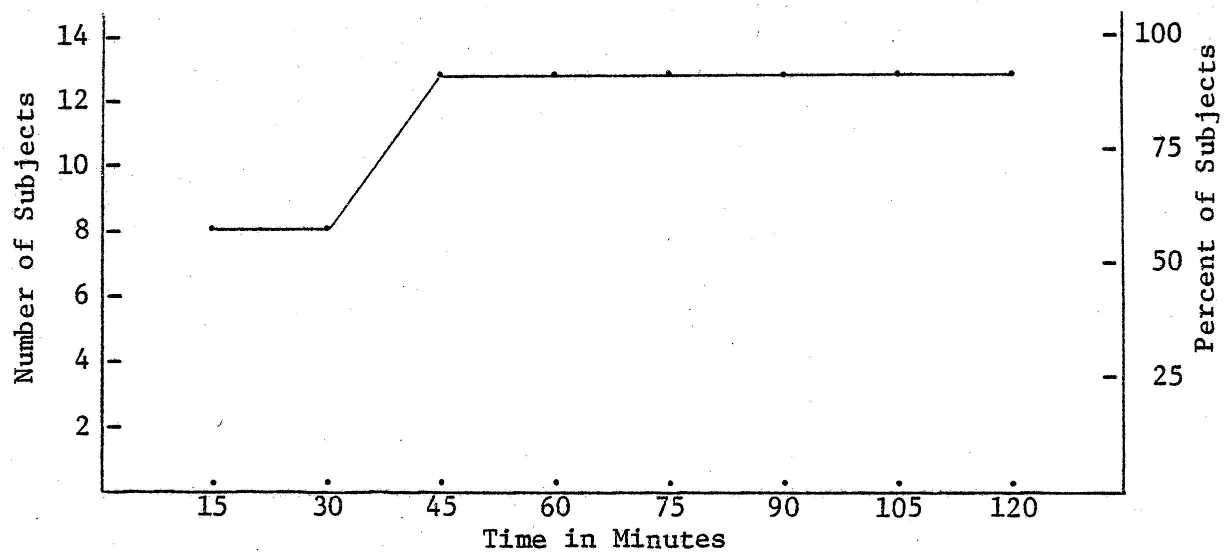
Maternal temperature. The review of literature revealed that the higher the maternal temperature (MT), the higher the infant's temperature would be. An analysis of correlation between MT and TST for this study showed an 80 per cent correlation between a more-than-average MT and early TST (Table 10). This inversely proporational relationship was also seen at each individual level of MT (Table 11). Figure 2 illustrates this relationship. An analysis of partial correlation established the significance of this relationship at the p=0.05 level (Table 12).

Based on these analyses it could be said that the amount of time it takes for the infant's temperature to stabilize is inversely proportional to maternal temperature.

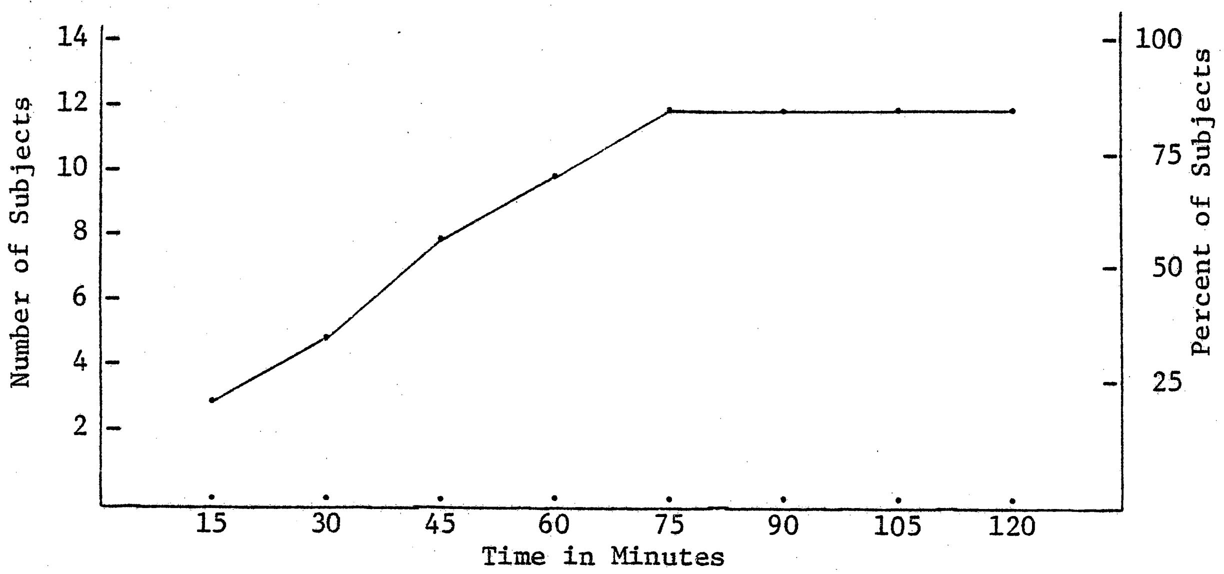
Table 9

Number and Per Cent of Subjects at Stabilized Temperature at 15-Minute Intervals After Birth

	Water Bath		Radiant Heater	
	Number	Per Cent	Number	Per Cent
15	8	53	3	20
30	8	53	5	33
45	13	87	8	53
60	13	87	10	67
75	13	87	12	80
90	13	87	12	80
105	13	87	12	80
120	13	87	12	80



WB Group



RH Group

Figure 1

Cumulative Number and Percent of Subjects Attaining 98° Axillary Temperature in the Two-Hour Study

Table 10

Correlation Between Maternal Temperature and Temperature Stabilization Time

		TST +	TST −
MT	+	5 (17%)	13 (43%)
MT	−	11 (37%)	0 (0%)
MT	o	1 (3%)	0 (0%)

\+ = more than average
− = less than average
o = average

Table 11

Correlation Between Each Level of Maternal Temperature and Temperature Stabilization Time

		Maternal Temperatures 97.0-97.4	97.5-97.9	98.0-98.5	98.6-99.0
TST	−	0	0	6	7
TST	+	8	3	3	3
Total	#	8	3	9	10
Total	% +	100%	100%	33%	30%

% + = Percent of subjects with more than average TST

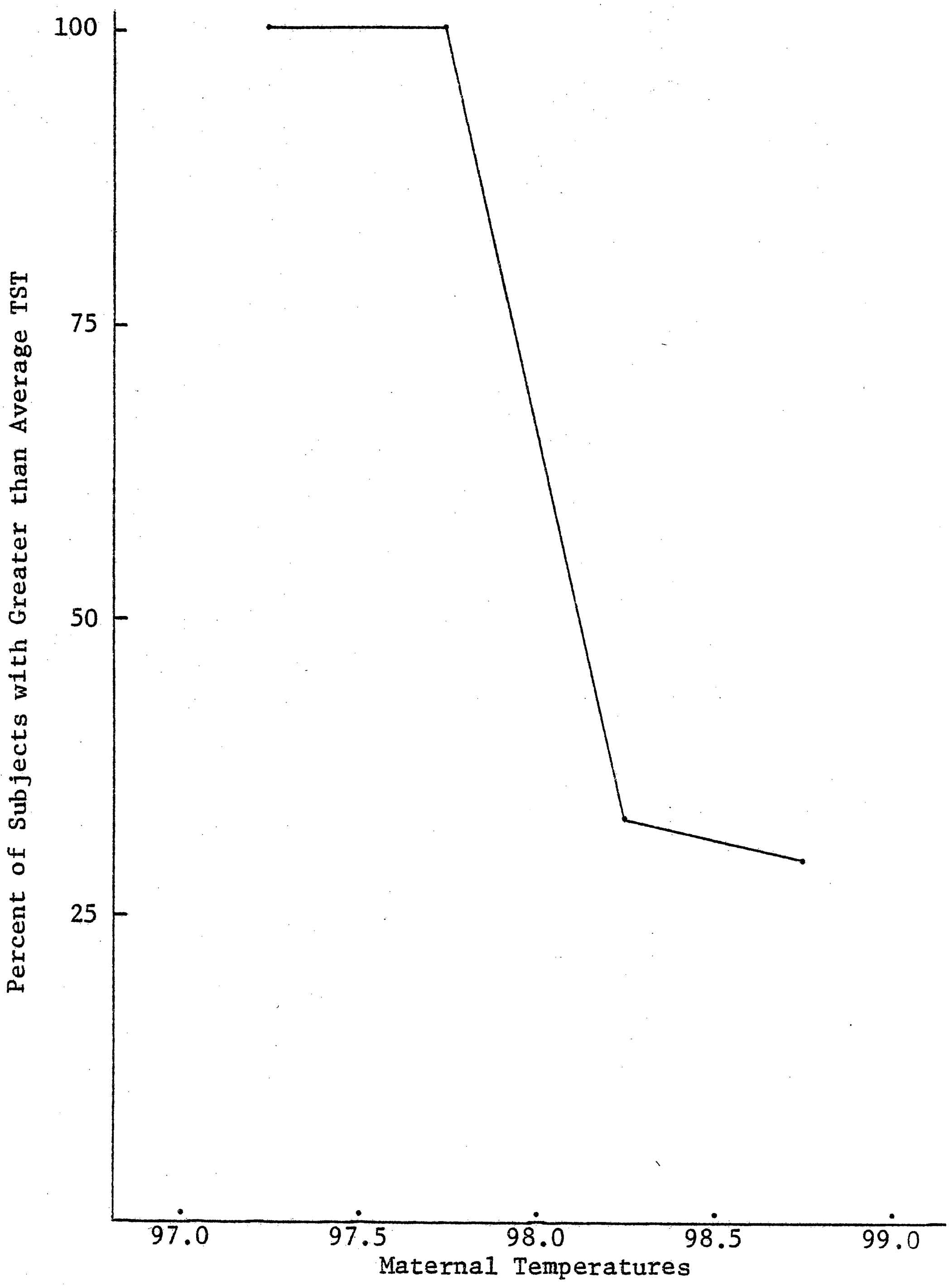


Figure 2

Correlation Between Each Level of Maternal Temperature and Percent of Subjects at Greater-Than-Average Temperature Stabilization Time

Table 12

Correlations of Covariants

Dependent Variable	Covariant	F Value	L.S.
TST	MT	7.33	0.05
	Sa/Wt ratio	0.82	--
	TI	6.83	0.05
2HT	MT	14.77	.001
	Sa/Wt ratio	0.08	--
	TI	11.33	.001

When compared to average MT (98.1 degrees), the WB and RH groups had basically the same number of subjects with greater than average readings and less than average readings (Table 13). The WB mean MT was 98 degrees, as compared to the RH group average MT of 98.2 degrees (Table 2). Based on these comparisons, the WB and RH groups seemed to be well matched as far as MT was concerned. Therefore, even though there was a large correlation between MT and TST, this factor should not have affected the results of the comparison analysis done involving the first hypothesis.

Surface area per weight ratio. The literature also suggested that Sa/Wt ratio and TST should be directly proporational, i.e., the infant with a large Sa/Wt ratio will take longer to stabilize. An analysis comparing data of TST and Sa/Wt ratio showed only a 30 per cent correlation between early TST and low Sa/Wt ratio, and thus, did not substantiate literature findings (Table 14). Because of the lack of correlation displayed between the two factors, the Sa/Wt ratio could not be considered to have had an effect on the analysis involving the first hypothesis.

Time interval. Much of the literature reviewed stated that the newborn infant loses a large amount of body heat at birth and should be placed in a warmed environment as quickly as possible. The relationship between the TI between birth and warming, and TST should be directly proportional, i.e., the more quickly the infant is placed in a warm environment, the sooner his temperature should stabilize. The data

Table 13

Group Maternal Temperatures Compared to Mean Maternal Temperature

	Water Bath Group	Radiant Heater Group
< mean MT	5	6
> mean MT	10	8
mean MT	0	1

Table 14

Correlation Between Sa/Wt Ratio and Temperature Stabilization Time

		TST	
		+	-
Sa/Wt	+	6 (20%)	6 (20%)
	-	6 (20%)	3 (10%)
	o	5 (17%)	4 (13%)

\+ = more than average
\- = less than average
o = average

gathered in this study did not appear to support the statement of direct correlation. There was only a 3 per cent difference in TST between subjects with a less than average TI and those with a greater than average TI (Table 15). However, an analysis of partial correlation revealed that a direct relationship does exist between the two variables at the p=0.05 level of significance (Table 12).

Based on this analysis it could be stated that: The amount of time it takes for the infant's temperature to stabilize is directly proportional to the time interval between birth and warming.

When compared to average TI of three minutes, the WB and RH seemed to be fairly well matched (Table 16). This matching was not indicative of the true relationship between the TI's of the two groups, however. The mean TI of the RH group was substantially shorter than the mean TI of the WB group. This was reflected in the mean TI's for the two groups: 3.6 minutes for the WB group and 2.13 minutes for the RH group (Table 4). Because of this discrepancy and the correlation shown between TI and TST, the analysis involving the first hypothesis could have been affected. However, since a significant difference was found between the two groups' TST, the influence of the TI discrepancy could not change the analysis of the first hypothesis.

Combined factors. One final analysis incorporating all of these extraneous variables was done to determine any relationship between the correlational powers of the separate factors when they were combined. By doing this, the factor exhibiting the strongest influence on the TST could be identified and rules could be made concerning the relationships of factoral strength (Appendix K).

Table 15

Correlation Between Time Interval and Temperature Stabilization Time

		TST	
		+	-
TI	+	6 (20%)	5 (17%)
	-	7 (23%)	5 (17%)
	o	4 (13%)	3 (10%)

\+ = more than average
\- = less than average
o = average

Table 16

Group Time Interval Compared to Mean Time Interval

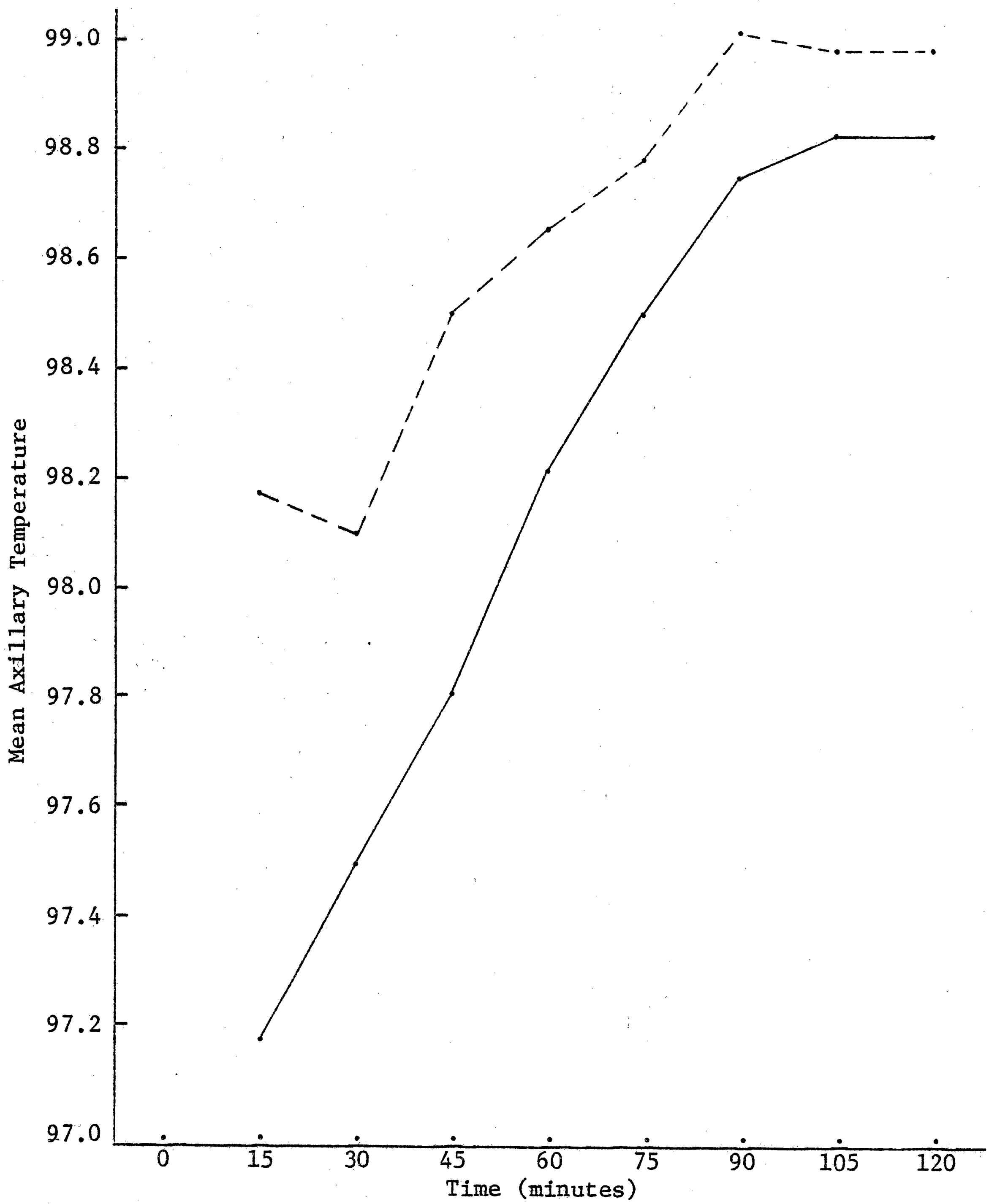
	Water Bath Group	Radiant Heater Group
< mean TI	3	9
> mean TI	7	3
mean TI	5	3

There was a 40 per cent correlation between a large MT, small TI, small Sa/Wt ratio and early TST (or the opposite). MT was dominant over TI and Sa/Wt ratio in 26 per cent of the cases. Also, MT and Sa/Wt ratio were dominant over TI in 7 per cent of the cases, though MT and TI dominated Sa/Wt ratio in 7 per cent of the cases. TI was dominant in 10 per cent of the cases. There were three cases (10%) where no correlational explanation was available. This analysis supported the findings in the previous sections, stating that MT has the highest amount of correlation with TST of the three extraneous factors.

Hypothesis II--Primary Analysis

The second hypothesis for this study was: There will be no significant difference (p=0.05) between the body temperatures of the two groups at the end of the two-hour testing period. This hypothesis reflected the clinical significance of the study, since noting the presence or absence of a difference at two hours gives the clinician definitive feedback as to how substantially the water bath, as compared to the radiant heater, affects temperature regulation. The two-hour temperature readings for each group were averaged, deriving a mean temperature for each group (Table 5). The mean temperatore of the WB group at two hours was 98.88 degrees, whereas the mean temperature of the RH group was 98.81 degrees (Figure 3).

An analysis of covariance between study group and 2HT demonstrated that the water bath had significantly higher two-hour temperatures (p=0.05) than the radiant heater group (Table 8). Therefore, the second hypothesis was rejected.



---=WB group
——=RG group

Figure 3

Graphic Illustration of the Mean Axillary Temperatures of the Two Study Groups at Each 15-Minute Interval

Hypothesis II—Secondary Analysis

Maternal temperature. The review of literature indicated that there is a direct correlation between the MT and fetal temperature, and thus, the baby's temperature at birth. An analysis was done to determine whether this correlation extended beyond birth, to two hours after birth. The analysis showed a 70 per cent direct correlation between MT and 2HT in the infant (Table 17). This direct correlation was also seen at each level (Table 18). Figures 4 and 5 illustrate this direct relationship. An analysis of partial correlation established the significance of this relationship at the p=.001 level (Table 12).

Based on these analyses, it could be stated that: Two-hour infant temperature is directly proportional to maternal temperature.

It was observed in an earlier section (Table 13) that MT's were fairly well matched for the two study groups. Therefore, it appears that even though a high correlation exists between MT and 2HT, this relationship did not affect the comparison made between the WB and RH groups in the second hypothesis.

Surface area per weight ratio. The review of literature revealed that a high Sa/Wt ratio in the newborn is associated with increased heat dissipation to the environment. An analysis was done to determine whether this correlation was supported by the study data. There was a 43 per cent correlation between an inversely proportional relationship involving these factors, and a 27 per cent lack of correlation (Table 19). The inversely proportional correlation was also seen in looking at each individual Sa/Wt ratio reading (Table 20). Figures 6 and 7 illustrate

Table 17

Correlation Between Maternal Temperature and Two-Hour Infant Temperature

		2HT	
		+	-
MT	+	13 (43%)	5 (17%)
	-	3 (10%)	8 (27%)
	o	0 (0%)	1 (3%)

\+ = more than average
\- = less than average
o = average

Table 18

Correlation Between Each Level of Maternal Temperature and Two-Hour Temperature

		Maternal Temperatures			
		97.0-97.4	97.5-97.9	98.0-98.4	98.5-99.0
2HT	-	6	2	3	3
	+	2	1	4	9
Total	#	8	3	7	12
	% +	25%	33%	57%	75%

% + = Percent of subjects with more than average 2HT

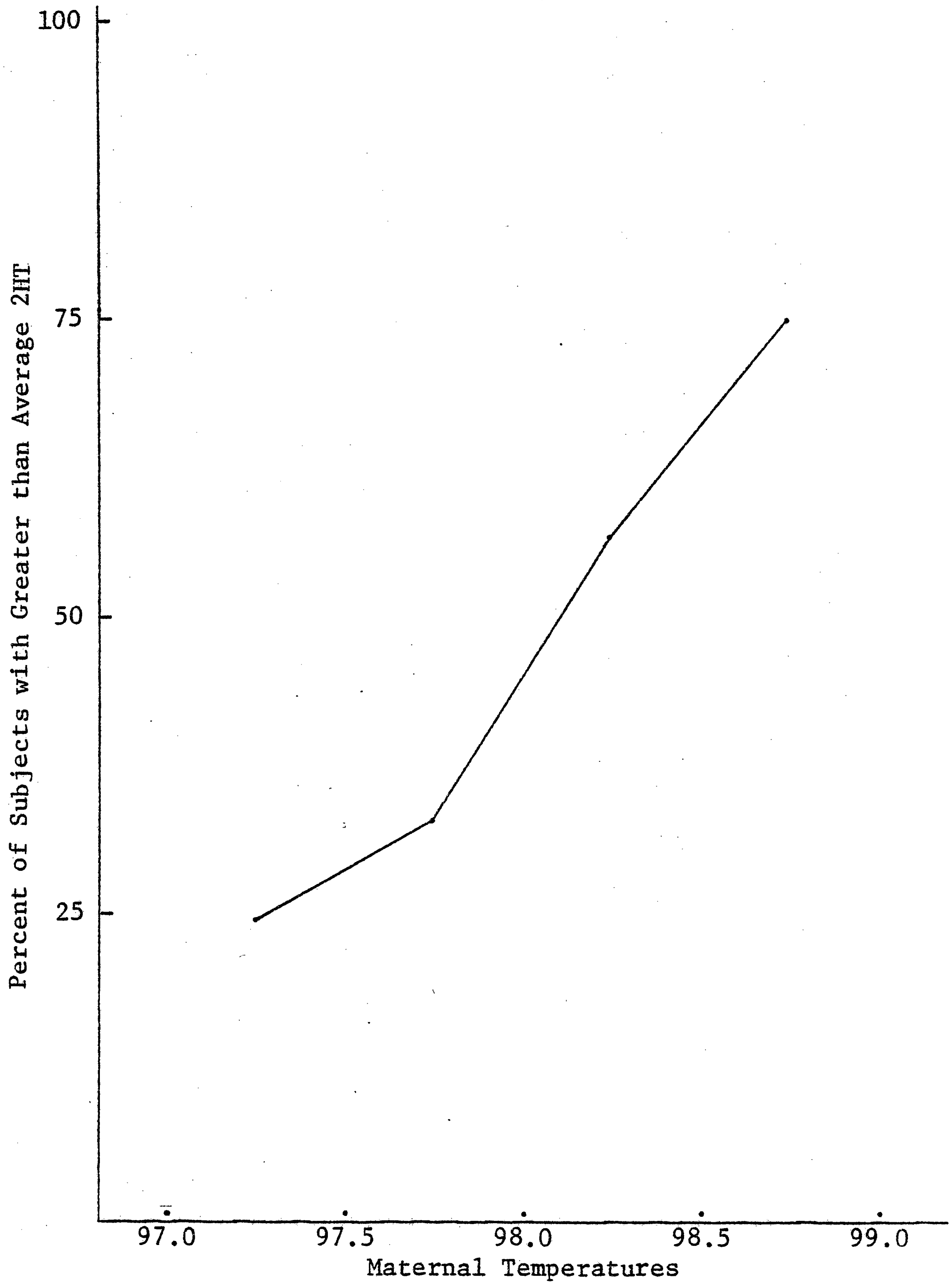


Figure 4

Correlation Between Each Level of Maternal Temperature and Percent of Subjects at Greater-Than-Average Two-Hour Temperature

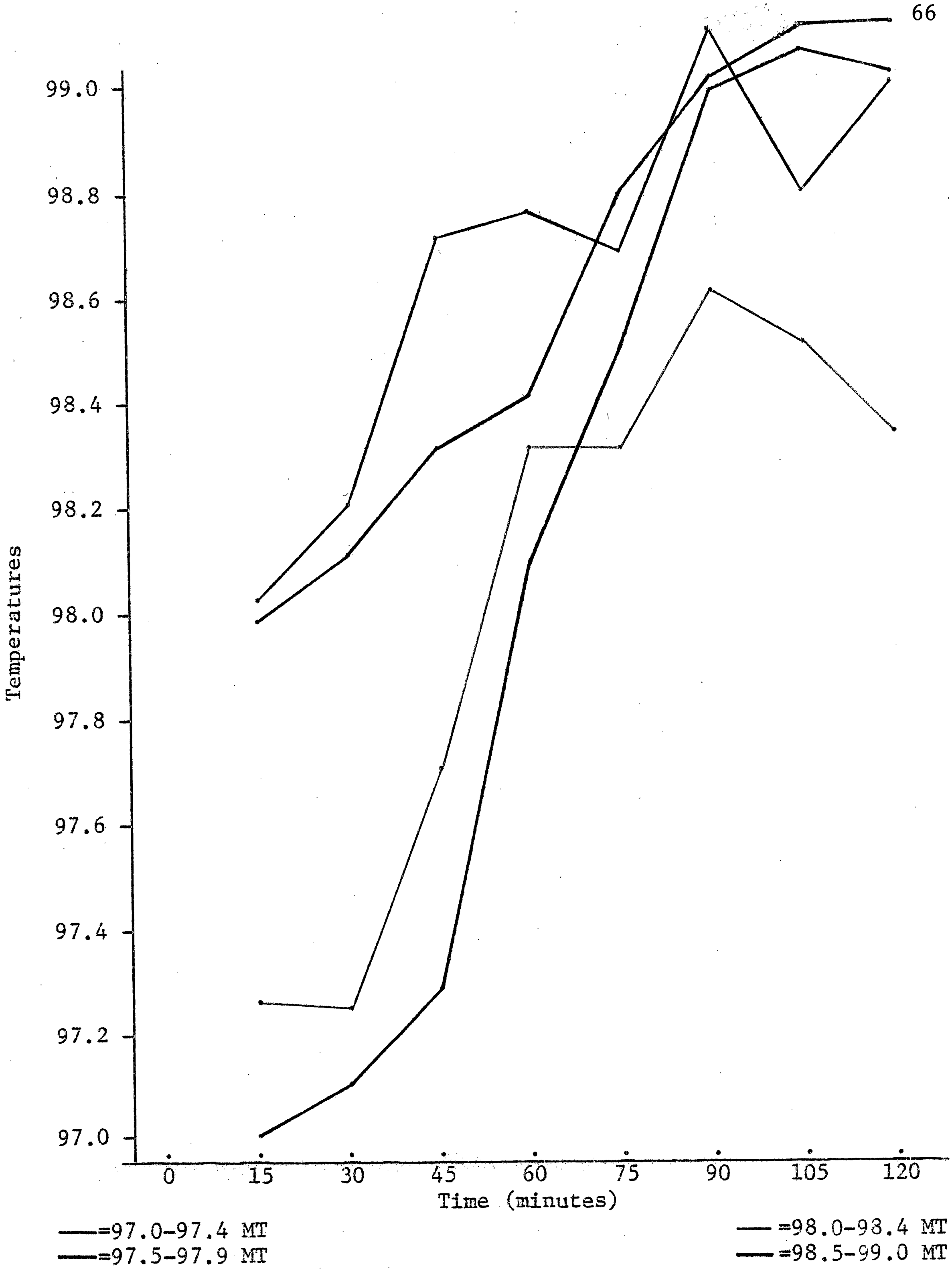


Figure 5

Graphic Illustration of the Mean Axillary Temperatures of Four Levels of Maternal Temperature at Each 15-Minute Interval

Table 19

Correlation Between Sa/Wt Ratio and Two-Hour Infant Temperature

		2HT	
		+	-
Sa/Wt	+	5 (17%)	7 (23%)
	-	6 (20%)	3 (10%)
	o	5 (17%)	4 (13%)

+ = more than average
- = less than average
o = average

Table 20

Correlation Between Each Level of Sa/Wt Ratio and Two-Hour Temperature

		Surface Area/Weight Ratio				
		.026	.027	.028	.029	.030
2HT	-	1	2	4	5	2
	+	2	4	5	4	1
Total	#	3	6	9	9	3
	% +	67%	67%	56%	44%	33%

% + = Per cent of subjects with more than average 2HT

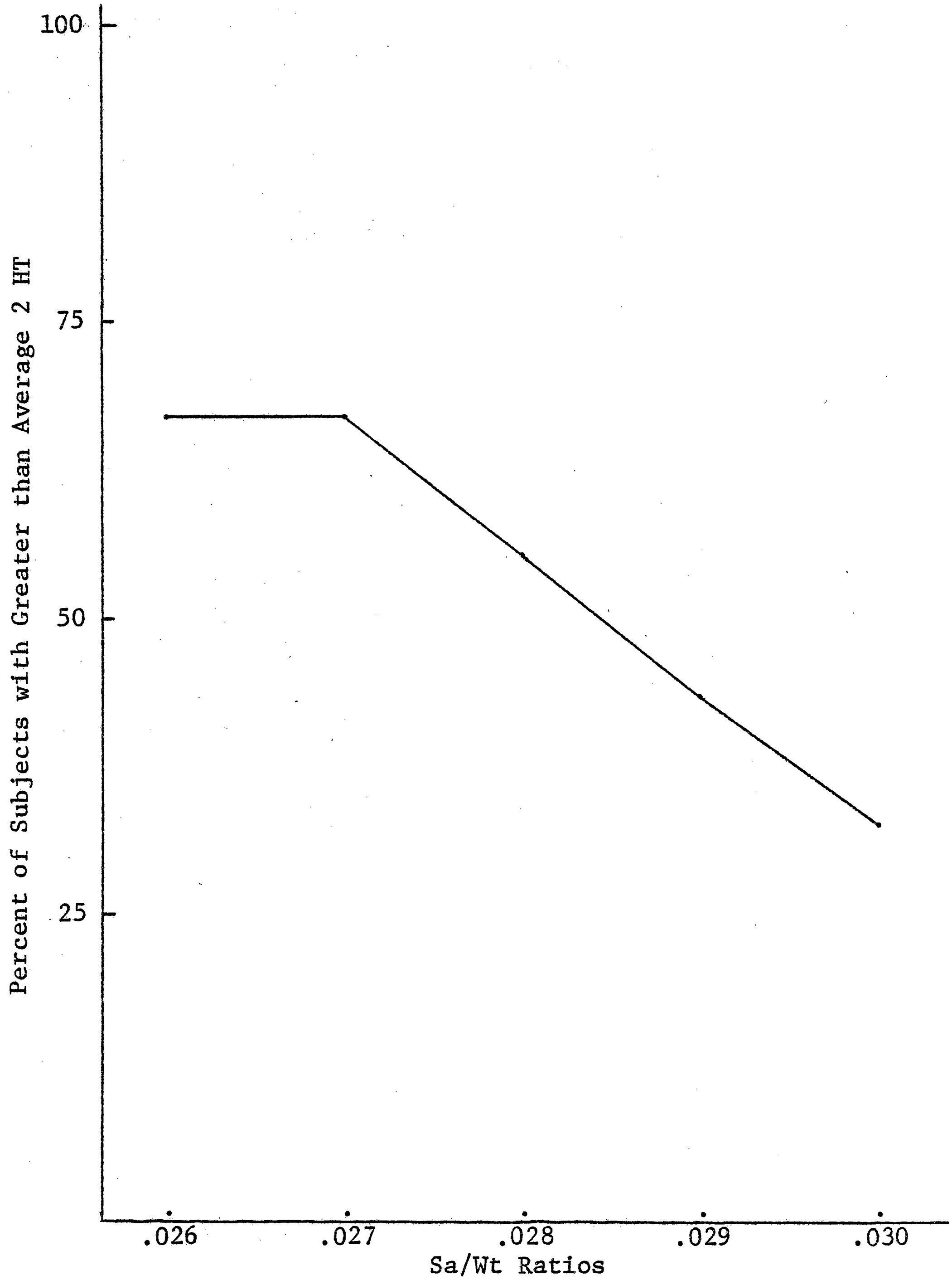


Figure 6

Correlation Between Each Level of Sa/Wt Ratio and Percent of Subjects at Greater-Than-Average Two-Hour Temperature

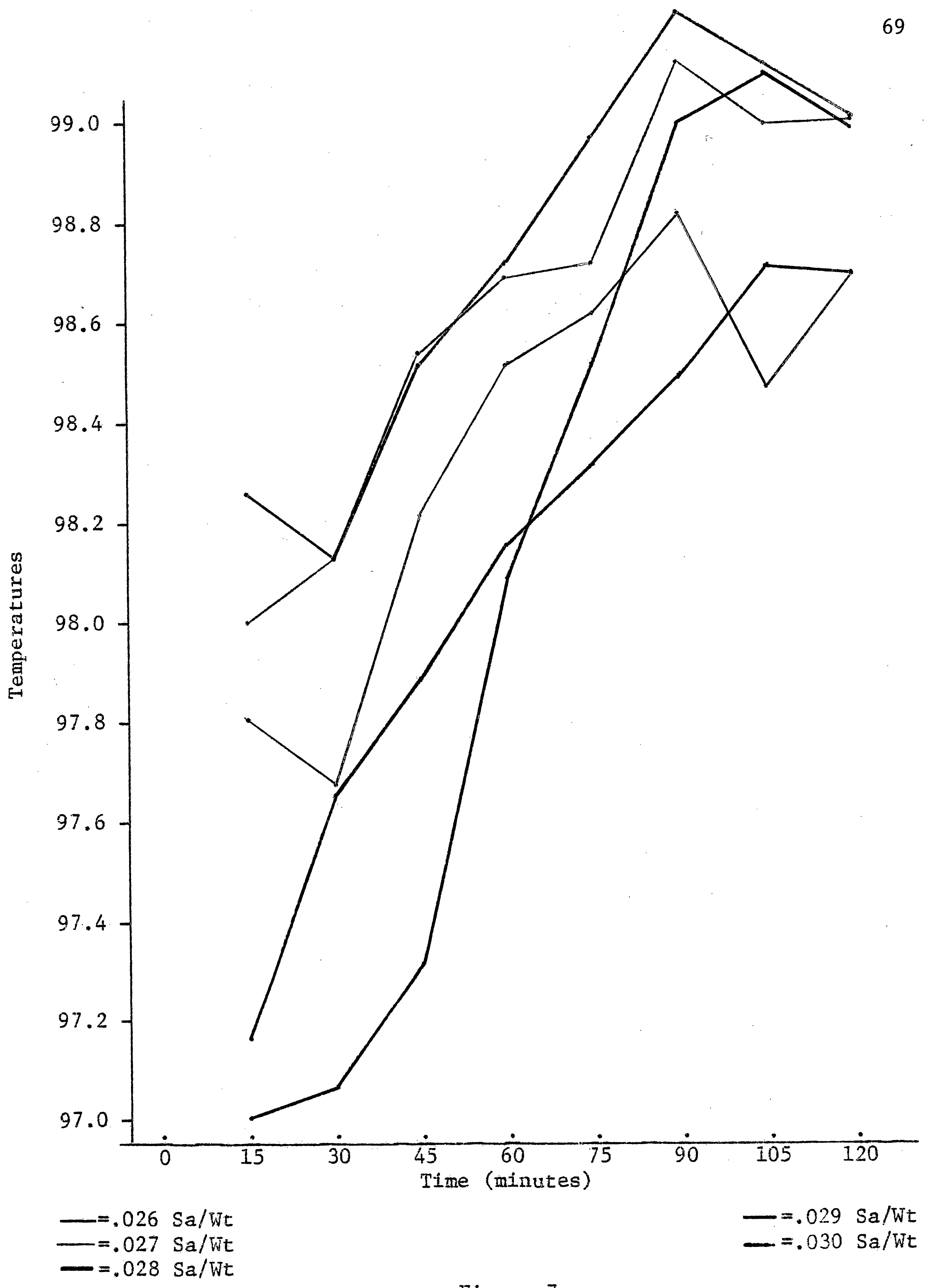


Figure 7

Graphic Illustration of the Mean Axillary Temperatures of Each Level of Sa/Wt Ratio at Each 15-Minute Interval this relationship. Based on this analysis it could be stated that: Two-hour infant temperature is inversely proporttional to surface area per body weight ratio.

When compared to average Sa/Wt ratio of .028 square meters, the WB and RH groups had basically the same number of subjects with greater than average readings and less than average readings (Table 21). For both groups, a mean Sa/Wt ratio was computed as .028 square meters (Table 3). Based on these comparisons, the WB and RH groups seemed to be well matched according to Sa/Wt ratio. Therefore, even though a correlation was seen between Sa/Wt ratio and 2HT, this factor should not have affected the results of the comparison analysis done involving the second hypothesis.

Time interval. Analysis was done to determine whether there was a direct correlation between the number of minutes passing before warming began and the 2HT readings for the infants in the study. The analysis showed a 54 per cent direct, inversely proportional correlation between TI and 2HT (Table 22). There was also a substantial inversely proportional correlation with 2HT at each TI level (Table 23). Figures 8 and 9 illustrate this correlation. An analysis of partial correlation established the significance of this relationship at the p=.001 level (Table 12).

Based on these analyses, it could be stated that: Two-hour infant temperature is inversely proportional to time interval.

It was observed in an earlier section (Table 16) that the mean TI for the RH group was substantially shorter (2.13 minutes) than the

Table 21

Group Sa/Wt Ratio Compared
to Mean Sa/Wt Ratio

	Water Bath Group	Radiant Heater Group
< mean TI	4	5
> mean TI	7	5
mean TI	4	5

Table 22

Correlation Between Time Interval and
Two-Hour Infant Temperature

		2HT	
		+	-
TI	+	3 (10%)	7 (24%)
	-	9 (30%)	3 (10%)
	o	4 (13%)	4 (13%)

+ = more than average
- = less than average
o = average

Table 23

Correlation Between Each Level of Time Interval and Two-Hour Temperature

		Time Interval					
		1	2	3	4	5	6
2HT	−	2	1	4	4	1	2
	+	6	3	4	2	1	0
Total	#	8	4	8	6	2	2
	% +	75%	75%	50%	33%	50%	0%

% + = Per cent of subjects with greater than average 2HT

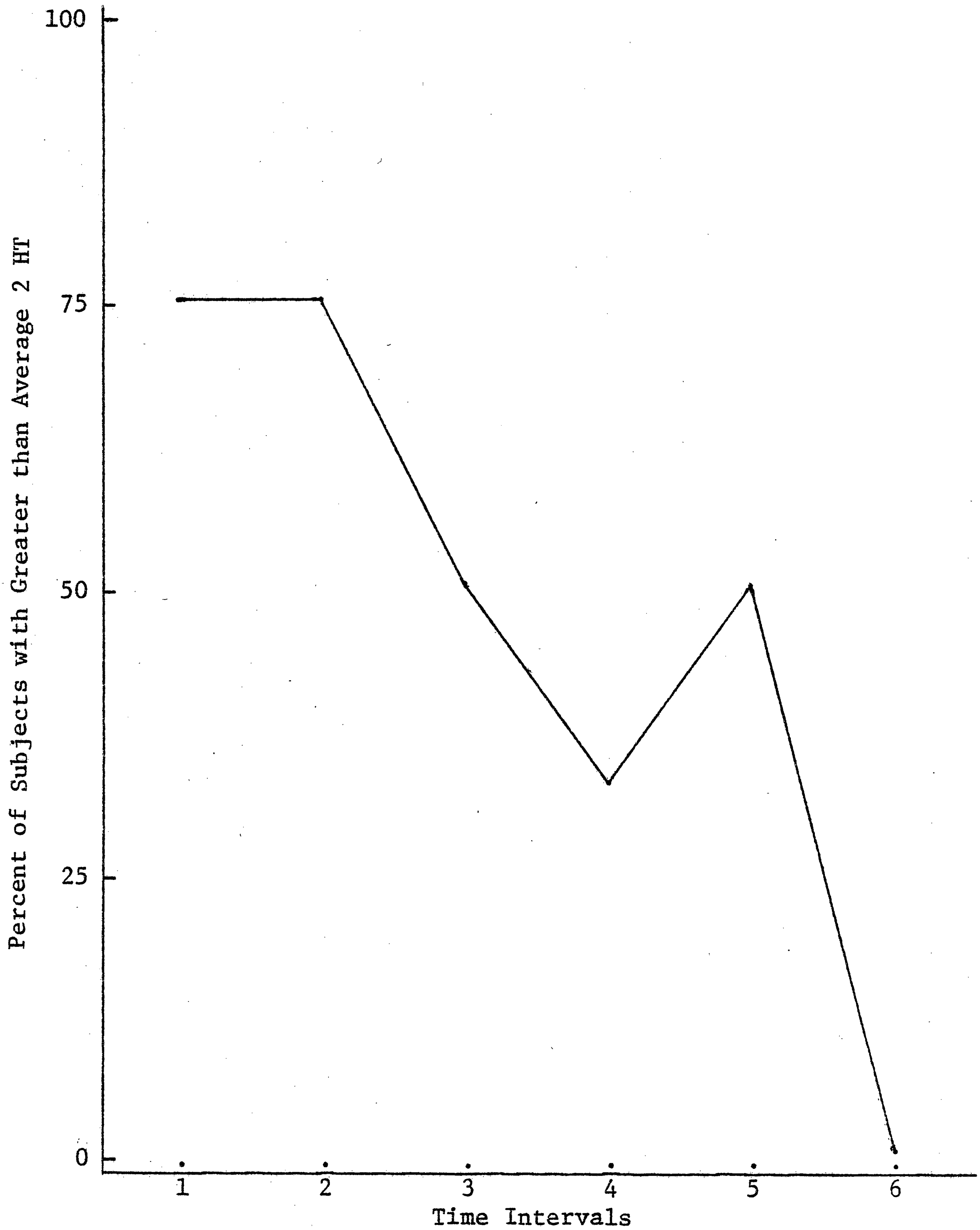


Figure 8

Correlation Between Each Level of Time Interval and Percent of Subjects at Greater-Than-Average Two-Hour Temperature

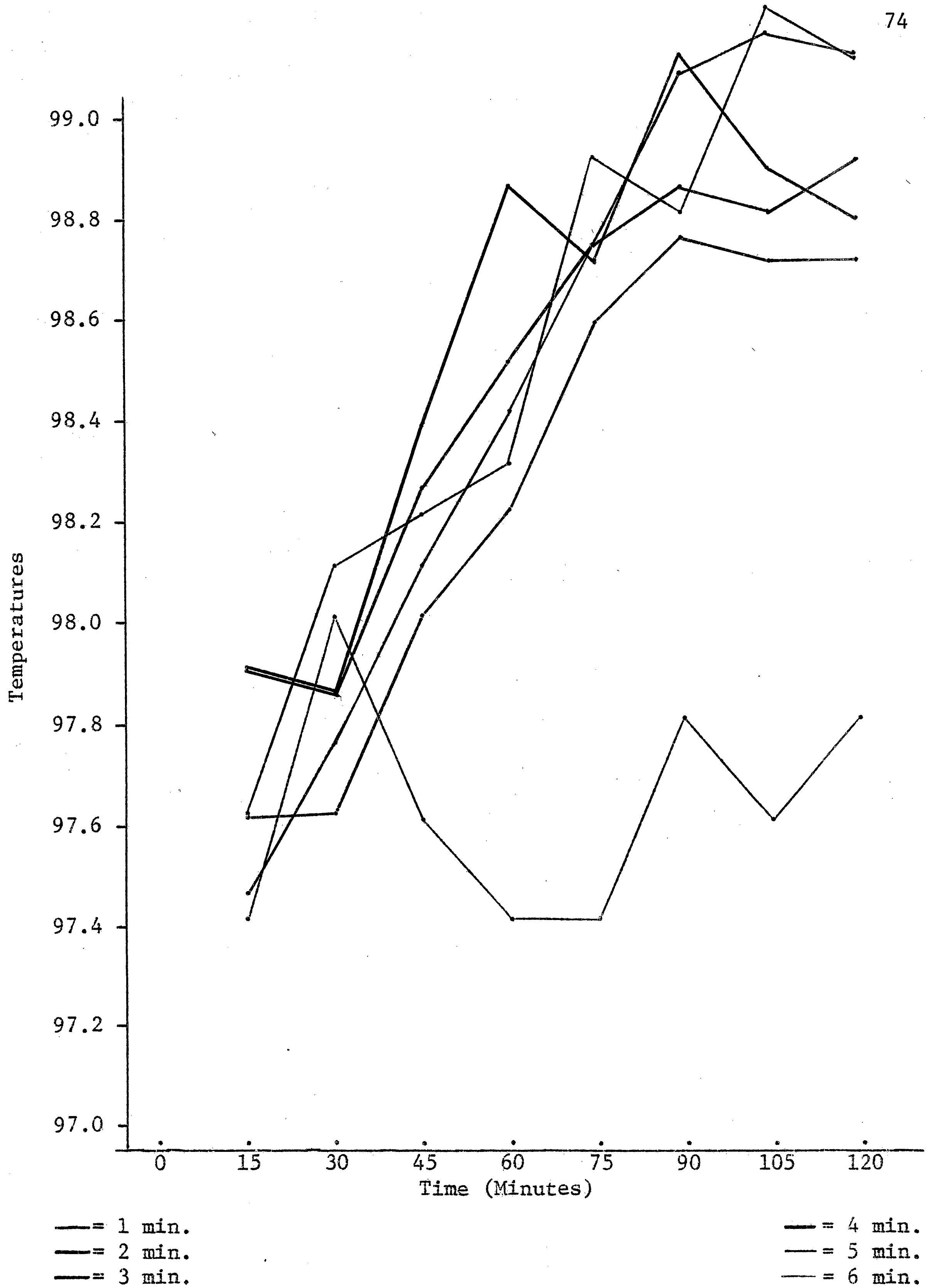


Figure 9

Graphic Illustration of the Mean Axillary Temperatures of Each Level of Time Interval at Each 15-Minute Interval mean TI of the WB group (3.6 minutes). Because of this discrepancy and the correlation shown between TI and 2HT, the analysis involving the second hypothesis could have been affected. However, since a significant difference was found between the two groups' 2HT, the influence of the TI discrepancy could not change the analysis of the second hypothesis.

Combined factors. A final analysis was done to determine the highest degree of correlation when all factors were analyzed together and to determine the most influential factor. Data from each subject was compared to the averages for each factor and rated as greater than average, less than average, or average (Appendix L).

There was a 40 per cent correlation between a high MT, low TI, low Sa/Wt ratio, and high 2HT (or the opposite). A further 20 per cent correlation existed between all factors excluding MT. MT was dominant in 17 per cent of the cases. TI was dominant over other factors in 10 per cent of the cases, whereas SA/Wt ratio dominated in 6.5 per cent of the cases. There were two cases in which no apparent correlation existed.

Temperature Stabilizing Time and Two-Hour Temperature

One final correlational analysis was done using the temperature readings of the subjects. The relationship between the time taken for each infant to stabilize (TST) and the two-hour temperature (2HT) was found to be an inversely proportional correlation. Figure 10 shows this relationship.

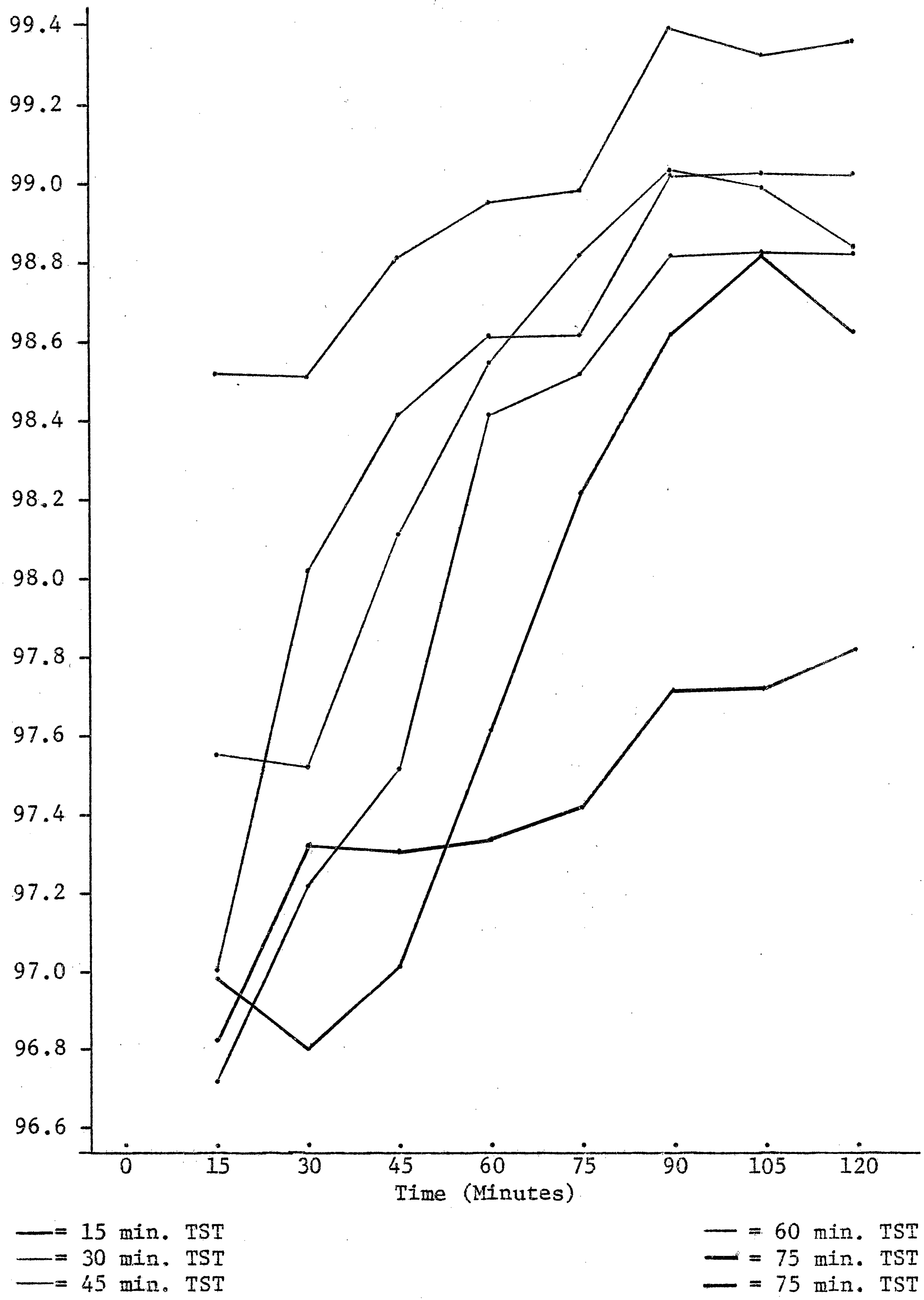


Figure 10

Graphic Illustration of the Relationship Between TST and 2HT

SUMMARY

In this chapter comparisons were made of the stabilization times and two-hour temperatures of 30 normal newborns, divided equally between two study groups. The different warming environments were evaluated according to their effect on these two readings for the study subjects.

It was found that the water bath group had significantly shorter temperature stabilization times ($p=.001$) and significantly higher two-hour temperatures ($p=0.05$) than the radiant heater group.

Several factors were found to have a high percentage of correlation with TST and 2HT when compared between the factor's mean value and higher than or lower than mean TST and 2HT. Statistical analysis of these covariate factors (MT, Sa/Wt ratio, and TI) showed that MT and TI correlated at a $p=0.05$ level with TST. The same two factors correlated at a $p=.001$ level with 2HT.

Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY

The purpose of this study was to compare the effects of the warm water bath and the radiant heater on the axillary temperatures of normal newborns. The 30 subjects studied were equally divided between the two groups. Hypotheses for this study stated a lack of significant difference between the stabilization times and two-hour temperatures in the water bath and radiant heater groups.

A selected review of literature was done in order to establish a scientific basis for the study's investigation. Areas reviewed included: 1) body temperature; 2) avenues of heat loss; 3) thermal gradients; 4) thermoregulation in the newborn; 5) factors impairing regulation; 6) thermal environment at birth, and 7) standard warming techniques.

A comparative, quasi-experimental approach was used. Subjects were placed in either a warm water bath or under the overhead radiant heater for 10 minutes immediately after birth. Axillary temperatures were taken for each subject at 15-minute intervals for two hours after birth. Both groups of babies remained with their parent(s) in the recovery area for two hours after birth. During this time, all babies remained wrapped and in close body contact constantly.

The data collected for the study were analyzed and interpreted as follows: 1) effects of the WB and the RH on TST; 2) correlation between MT, TI, Sa/Wt and TST; 3) possible effect of MT, TI, or Sa/Wt correlations with TST on the first hypothesis analysis; 4) factoral dominance in relation to TST; 5) effects of the WB and the RH on 2HT; 6) correlation between MT, TI, Sa/Wt and 2HT; 7) possible effect of MT, TI or Sa/Wt correlations with 2HT on the second hypothesis analysis; 8) factoral dominance in relation to 2HT; and 9) correlation between TST and 2HT.

The hypotheses of the study stated:

1. There will be no significant difference (p=0.05) between the amount of time passing before temperature stabilization occurs in the two groups.

2. There will be no significant difference (p=0.05) between the body temperatures of the two groups at the end of the two-hour testing period.

Findings of the study showed mean temperature stabilization time of 26.5 minutes for the WB group, as compared to 42.5 minutes in the RH group. This difference was significant at the p=.001 level. Therefore, the first hypothesis was rejected. It was also shown that 87 per cent of the WB group, and 80 per cent of the RH group stabilized within the two-hour study.

Mean two-hour temperatures for the two groups were 98.88 degrees for the WB group, and 98.81 degrees for the RH group. These findings were significant at the p=0.05 level. Therefore, the second hypothesis was also rejected.

Several extraneous factors (covariates) were found to have a direct effect on stabilization time and two-hour temperature. MT was found to be inversely proportional to TST, at a significance level of p=.05. MT was also found to be directly proportional to 2HT, at a level of significance of p=.001. TI was directly proportional to TST at a level of p=.05 and was inversely proportional to 2HT at a p=.001 level.

When the correlational dominance of several extraneous factors was tested, MT was found to dominate other factors in the strength of its correlational relationship with TST.

A correlation between TST and 2HT also showed an inversely proportional relationship.

CONCLUSIONS

The following conclusions were based on the analysis of the findings of this study. Validity of these conclusions, and thus their utilization, must take into account the small sample size involved in the study. It was concluded that:

1. The WB group had significantly shorter temperature stabilization times than the RH group.

2. The WB group had significantly higher two-hour temperatures than the RH group.

IMPLICATIONS FOR NURSING

The author's intention in conducting this study was not to advocate the use of the water bath, but rather, to clarify one of its clinical effects. From the analysis of the hypotheses, it would seem that delivery room personnel may use the warm water bath without fear of adverse effects on the temperature of the newborn. Both temperature stabilization and temperature at the end of two hours compared favorably between the two groups. In fact, the water bath seemed to appear more effective for warming babies than the overhead radiant heater.

The analyses of partial correlation involving the covariates in the study also gave helpful input for delivery room personnel. The high correlational relationship TI had with the dependent variables demonstrated that an attempt should be made to place the infant in its warming environment as soon after delivery as possible. Nurses should also be aware that the maternal temperature has a significant effect on both TST and 2HT. Therefore, babies of mothers with low temperatures should be treated especially carefully to preserve body heat.

RECOMMENDATIONS FOR FURTHER RESEARCH

The following recommendations were made based directly on the findings of this study:

1. That a similar study be conducted using a device to constantly monitor and regulate temperature in the water bath and radiant heaters.

2. That a similar study be conducted using mean skin temperature readings from six body sites for comparison.

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APPENDIX A

LETTER TO THE DIRECTOR OF NURSING SERVICE

August 24, 1977

Ms. Gertrude Haussler
Director of Nursing Service
Loma Linda University
Loma Linda, Ca. 92354

Dear Ms. Haussler:

As a graduate student in Mother and Child Nursing, I am investigating the effectiveness of two procedures currently being used to warm newborns. The study is entitled Comparison of the Effects of Two Warming Procedures on Temperature Stabilization in Normal Newborns. This study is being done to meet part of the requirements for a master's degree in nursing at Loma Linda University. I am hereby requesting permission to involve patients from LLUMC in my study. My thesis committee chairman, Clarice Woodward, has approved this thesis, and I have also obtained approval from the Ethics in Nursing Research Committee.

The proposed research will be quasi-experimental in nature. It will involve two groups of normal term babies. One group will be warmed by a warm water bath after delivery. The other group will be warmed under a radiant heater after delivery. Temperature readings for each baby will be obtained every fifteen minutes for two hours after birth. No risk to the subjects is anticipated. After obtaining the physician's consent and approval to include each patient in the study, the parents' consent will be obtained following a thorough explanation of the study. Randomly-assigned numbers for identification will insure confidentiality. Right to withdrawal from the study without prejudice will also be assured for each subject.

With your permission, I would like to begin data collection for a pilot study during the first week of September. I expect to accomplish the entire data collection for the study by the end of Octo-- ber. I will be happy to make an appointment with you to discuss this research further if you desire, and to share the findings of the study after its completion. Space has been provided on the attached letter from the graduate program for your reply. Thank you for your assistance.

Sincerely,

Ann Morton, R.N., B.S.
Graduate Program in Nursing
Loma Linda University
School of Nursing

APPENDIX B

LETTER FROM THE AGENCY ALLOWING DATA COLLECTION

Loma Linda University Medical Center

Date: 9-7-77

Dear Ann Morton

Your request for permission to collect data for your research project at Loma Linda University Medical Center has been received and reviewed. The following action has been taken:

✓ You have my permission to conduct your study in our facility.

___ Your request has been temporarily denied pending provision of additional information.

___ Your request cannot be granted at this time.

Also, it will be necessary for you to:

___ Obtain permission from the attending physician since your study involves patients and/or their records.

9/23/77 ✓ Obtain additional permission from Bonnie Wissler and Marilyn Thurquest.

___ Notify and/or advise the following persons of your study.

___ Make an appointment with ______________ for additional discussion and information provision.

___ Other

If I can be of further help, please let me know.

Sincerely,

Gertrude Haussler

Gertrude L. Haussler, M.S.
Assistant Administrator
Nursing

APPENDIX C

APPROVAL FROM THE ETHICS COMMITTEE

LOMA LINDA UNIVERSITY
Graduate Program in Nursing

Date: August 17, 1977

Ann Morton
22275 De Berry
Grand Terrace, CA 92324

Dear Ann:

The Ethics in Nursing Research Committee has reviewed the proposal you submitted for a research study to partially fulfill the School of Nursing requirements for a Master of Science degree from Loma Linda University.

The committee has voted that your study is:

______ Approved as submitted.

__x__ Approved after the attached recommended changes have been made and a memo from your committee chairman to this effect has been received by the committee chairman.

______ Not approved as submitted to the committee. See the attached comments for recommended changes. Must be resubmitted prior to any data collection.

______ Deferred to: ___URACHE ___ Major Advisor ___ Research Chairman
___Other ___ Advisor

Please see attached comments regarding this action.

Please contact the Chairman of the Ethics in Nursing Research Committee if you have questions related to the decision of the Committee. If any changes are made in the hypothesis, tool, consent form, or the procedure for data collection, this proposal must be resubmitted to this Committee.

We pray that the Lord will continue to bless your endeavors.

Sincerely,

Evelyn L. Elwell

Evelyn L. Elwell, Chairman
Ethics in Nursing Research Committee

ELE:lw

Research Committee Chairman

RECOMMENDATIONS AND COMMENTS OF THE ETHICS IN NURSING RESEARCH COMMITTEE

Approved with following recommendations:

1. See revised Consent Form

2. Two consent forms if both parents are involved.

3. Revise information for better organization of content on Information for Parents.

APPENDIX D

APPROVAL FROM THE RESEARCH COMMITTEE

Graduate School FORM 1

THESIS OR DISSERTATION SUBJECT and GUIDANCE COMMITTEE

Name Ann Junkin Morton Degree sought M.S.

Major department or area of concentration Nursing

Thesis (dissertation) subject Comparison of the Effects of Two Warming Procedures on Temperature Stabilization in Normal Newborns

Guidance Committee: (The signature of a committee member indicates his willingness to serve and his approval of the thesis/dissertation subject and research design)

Clarice Woodward
Chairman

L. Frances Pride
Signature of Department Chairman

Date August 29, 1977

Signature of Graduate School Dean

Date 9/1/77

Copies for: Graduate School
Department
Each Guidance Committee Member
Student ✓

APPENDIX E

DATA COLLECTION SHEET

DATA COLLECTION FORM

Subject #________	Time born ________am/pm
Group ________	Time warming began________
Sex ________	Interval ________min.
Duration of Labor________hrs.	Temperatures (Axillary):
Gestational age ________wks.	At birth ________degrees
Mother's temp. ________(oral)	15 min ________degrees
Time taken ________am/pm	30 min ________degrees
	45 min ________degrees
Drugs taken during Labor and Deliv: (drug, dosage, time)	1 hr ________degrees
	1 hr/15 min ________degrees
	1 hr/30 min ________degrees
Type of Deliv. ________	1 hr/45 min________degrees
Position ________	2 hrs ________degrees
Anesthetic ________	
Weight of infant________kg.	Diabetic or Toxemic________
Length of infant________cm.	Apparent Anomalies ________
Surface area ________m^2	Postmaturity ________
Apgar (5 min.) ________	

APPENDIX F

CONSENT FORM

CONSENT FORM

A study is being conducted to determine the effectiveness of the warm water bath in helping a baby's temperature to stabilize. The baby's temperature will be taken under the arm every 15 minutes for 2 hours after delivery to compare the effectiveness of a warm water bath with radiant heating. During this time the baby will remain wrapped and in constant close body contact.

The information gained will help to determine if methods for infant warming can be improved. Any and all information obtained in this study will be treated in a confidential manner. You and/or your baby's name will not be attached to any information obtained.

I have considered the above statements and hereby give my free and voluntary consent to participate with my baby in The Effect of the Warm Water Bath on Axillary Temperature in Normal Newborns under the supervision of Ann Morton, R.N., graduate student in nursing, Loma Linda University, and in witness thereof I have signed this consent. I understand that I am free to withdraw by baby from participation in the study at any time without resulting in any prejudice toward me or my baby.

____
Signed

____
Date

____
Witness

APPENDIX G

INFORMATION TO THE PARENT SHEET

INFORMATION FOR THE PARENT

I am currently conducting a study at Loma Linda University Medical Center on procedures used to warm newborns. It is called The Effect of the Warm Water Bath on Axillary Temperature in Normal Newborns. In this study, I am comparing the effectiveness of the warm water bath and the radiant infant warmer in helping stabilize the newborn's body temperature. I want to see whether the water bath, currently being used in some hospitals, warms the baby as well as does the radiant heater, which is standardly used in most hospitals.

To do this, I will have two groups of normal babies. One group of babies will be placed in a warm water bath after the umbilical cord is clamped and cut. The second group will be placed under the radiant heater after the cord is clamped and cut. The babies will stay in their respective warm environments for 10 minutes. Then, they will be dried off, weighed, and wrapped in warmed blankets. This initial 10-minute period is essentially all that differentiates the treatment of the babies from each other.

After the babies are wrapped, they are handled normally. They can be held, played with, breastfed, etc. The only differences between the handling of these babies and babies not in the study from this point on are described below.

First, to compare the two warming procedures, temperature readings will be needed. Therefore, each baby's temperature will be taken every 15 minutes for 2 hours after birth. While you are still in the delivery room, you will have an opportunity to get a good look at your baby. Then to help prevent heat loss you will be asked not to unwrap the baby in the recovery room. You will also be asked to maintain constant, close body contact with your baby during the two-hour study period.

No risk is foreseen for any of the subjects included in this study. Numbers will be randomly assigned each subject so that anonymity will be preserved.

If you feel that you would like to have your baby participate in the study described above, please sign the consent form provided.

Thank you very much for your cooperation and help in accomplishing this study.

Most sincerely,

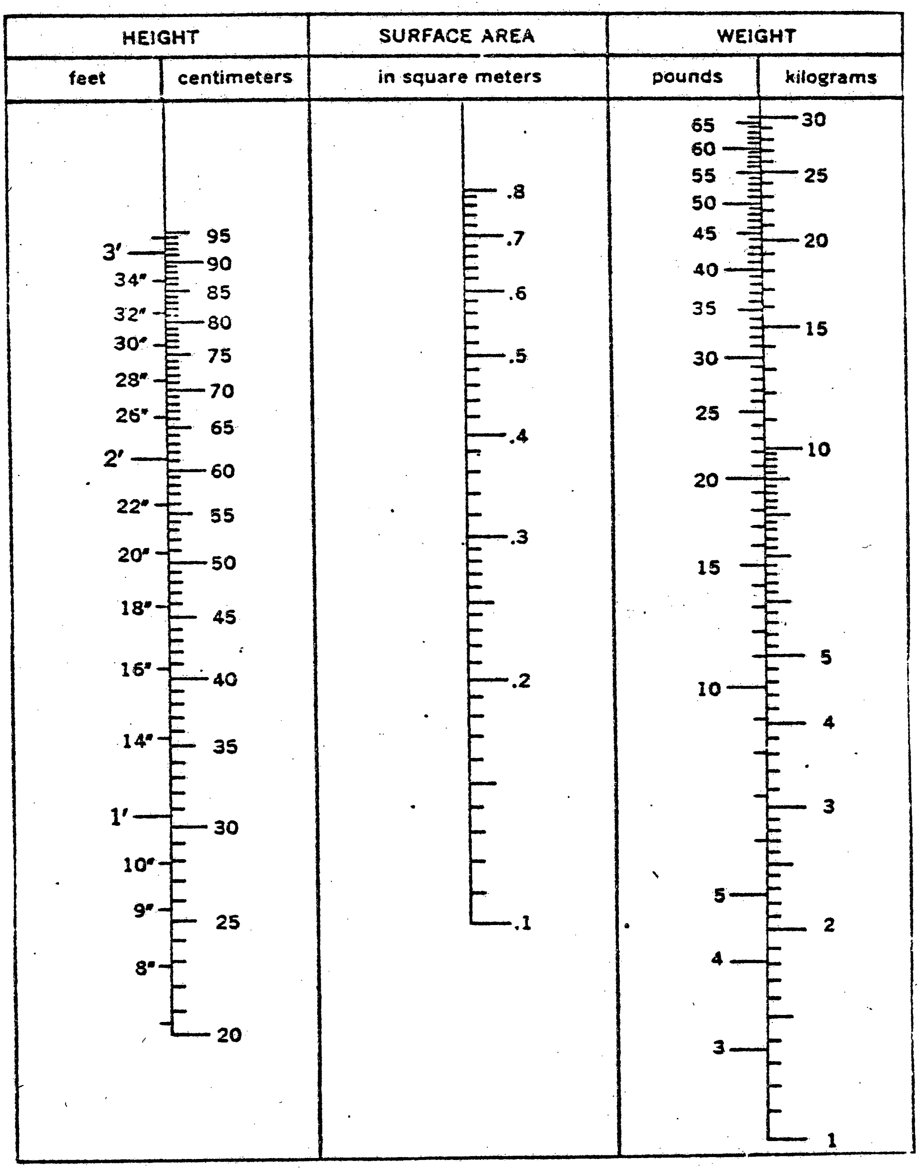
Ann Morton

Ann Morton, R.N., B.S.

APPENDIX H

NOMOGRAM FOR DETERMINING BODY SURFACE AREA

NOMOGRAM FOR ESTIMATING SURFACE AREA OF INFANTS AND YOUNG CHILDREN



To determine the surface area of the patient draw a straight line between the point representing his height on the left vertical sacle to the point representing his weight on the right vertical scale. The point at which this line intersects the middle vertical scale represents the patient's surface area in square meters. (Courtesy, Abbott Laboratories.)

APPENDIX I

DEMOGRAPHIC DATA SHEETS

Table 24

Demographic Data for 15 Subjects in the Water Bath Group

No.	Sex	Dur. Labor	Gest. Age	Mat. Temp.	Type Deliv.	Anesth.	Wt.	Length	S.A.	Sa/Wt	Apgar	Time Interval
1	M	8.5	40	97.0	S	L	8.75	20.5	.23	.026	9	2
2	M	9.5	40	98.6	LF	E	8.56	22.25	.24	.028	10	5
3	F	13	38	98.6	S	E	6.88	19.75	.20	.029	9	4
4	F	11.25	39	98.2	LF	E	7.44	18.75	.20	.027	9	3
7	M	13	38	98.5	S	P	8.06	20.5	.22	.028	9	6
11	F	5	38	98.2	S	L	6.88	19.25	.20	.029	9	4
14	M	3	40	97.4	S	L	8.0	20.5	.23	.029	9	3
15	M	8.5	41	97	S	L	8.75	20.5	.23	.026	9	2
18	M	4	39	97.4	S	L	8.0	20.5	.23	.029	9	3
19	F	11.5	37	98.6	S	E	6.88	19.75	.20	.029	9	4
20	F	8	40	98.2	S	L	6.88	19.25	.20	.029	9	4
22	M	13	40	98.5	S	P	8.06	20.5	.22	.028	9	6
24	F	3	38	97.4	S	E	8.0	20.5	.23	.029	9	3
29	M	14	38	98.6	LF	E	8.56	22.25	.24	.028	10	2
30	F	5.75	39	98.2	LF	L	7.44	18.75	.20	.027	9	3

Table 25

Demographic Data for 15 Radiant Heater Subjects

No.	Sex	Dur. Labor	Gest. Age	Mat. Temp.	Type Deliv.	Anesth.	Wt.	Length	S.A.	Sa/Wt	Apgar	Time Interval
5	M	4	41	98.6	LF	E	8.5	21.75	.23	.027	9	5
6	F	7	41	98.1	S	L	8.75	21.25	.23	.026	8	2
8	F	9	41	98.6	LF	L	7.69	19.25	.21	.027	9	1
9	F	4	38	98.4	S	L	7.25	19.13	.20	.028	9	1
10	F	5	40	97	S	P	7.56	19.75	.21	.028	9	4
12	M	11	40	99	S	L	7.06	18.75	.20	.029	9	1
13	F	16.5	38	97.7	S	E	6.25	18.75	.19	.030	9	3
16	F	5.75	40	97.2	S	P	8.25	20.13	.22	.027	9	3
17	M	8.5	38	99	LF	E	8.38	20.5	.23	.027	10	3
21	F	19	41	97	S	E	7.5	20.13	.21	.028	10	4
23	M	14	40	99	LF	E	7.88	20.75	.22	.028	9	1
25	F	4	40	97.8	S	L	6.75	18.75	.20	.030	9	1
26	M	13	38	99	LF	L	7.06	18.75	.20	.029	9	1
27	F	4	41	98.4	S	L	7.25	19.13	.20	.028	9	1
28	F	9.5	40	97.8	S	L	6.75	18.75	.20	.030	9	1

APPENDIX J

ACTUAL TEMPERATURES SHEETS

Table 26

Actual Axillary Temperatures for Each Water Bath Subject at 15-Minute Intervals for Two Hours After Birth

No.	15	30	45	60	75	90	105	120	mean
1	98.0	97.8	98.4	98.8	99.0	99.2	98.8	99.0	98.6
2	98.2	98.4	98.4	98.6	99.2	99.0	99.8	99.6	98.9
3	98.6	98.4	99.0	98.6	99.4	99.6	99.4	99.4	99.1
4	99.2	99.0	99.8	99.8	99.4	100.0	99.0	99.4	99.5
7	97.4	98.0	97.6	97.4	97.4	97.8	97.6	97.8	97.6
11	98.2	98.0	98.4	98.4	98.6	98.8	98.8	98.8	98.5
14	97.8	97.4	98.0	98.8	98.6	99.0	98.8	98.4	98.4
15	98.0	97.8	98.4	98.8	99.0	99.2	98.8	99.0	98.6
18	97.8	97.4	98.0	98.8	98.6	99.0	98.8	98.4	98.4
19	98.6	98.4	99.0	98.6	99.4	99.6	99.4	99.4	99.1
20	98.2	98.0	98.4	98.4	98.6	98.8	98.8	98.8	98.5
22	97.4	98.0	97.6	97.4	97.4	97.8	97.6	97.8	97.6
24	97.8	97.4	98.0	98.8	98.6	99.0	98.8	98.4	98.4
29	98.2	98.4	98.4	98.6	99.2	99.0	99.8	99.6	98.9
30	99.2	99.0	99.8	99.8	99.4	100.0	99.0	99.4	99.5

Table 27

Actual Axillary Temperatures for Each Radiant Heater Subject at 15-Minute Intervals for Two Hours After Birth

No.	15	30	45	60	75	90	105	120	mean
5	97.0	97.8	98.0	98.0	98.6	98.6	98.6	98.6	98.2
6	97.4	97.4	97.8	97.8	97.8	98.0	97.8	98.0	97.8
8	97.4	97.6	97.8	98.6	98.8	99.4	99.4	99.4	98.5
9	97.0	98.0	98.4	98.6	98.6	99.0	99.0	99.0	98.5
10	96.2	96.2	96.6	97.2	97.2	97.6	97.8	97.8	97.1
12	98.6	98.8	98.6	99.0	99.4	99.6	99.6	99.6	99.2
13	97.0	97.6	98.0	99.0	99.2	99.4	99.6	99.6	98.7
16	96.4	97.0	96.8	97.0	97.2	97.6	97.6	97.6	97.2
17	98.0	98.0	98.6	98.8	98.8	99.2	99.4	99.4	98.8
21	96.0	98.6	97.2	98.2	98.2	98.2	98.2	98.2	97.6
23	97.0	97.0	98.2	98.4	98.8	98.8	99.0	99.2	98.3
25	97.0	96.8	97.0	97.6	98.2	98.6	98.8	98.6	97.8
26	98.6	98.8	98.6	99.0	99.4	99.6	99.6	99.6	99.2
27	97.0	98.0	98.4	98.6	98.6	99.0	99.0	99.0	98.5
28	97.0	96.8	97.0	97.6	98.2	98.6	98.8	98.6	97.8

APPENDIX K

CORRELATION BETWEEN EXTRANEOUS VARIABLES AND TST

KEY TO TABLE 28

+ = greater than average

- = less than average

o = average

averages:

MT = 98.1 degrees

TI = 3 minutes

Sa/Wt = .028 square meters

TST = 34.2 minutes

analysis:

* = + MT
- TI
- Sa/Wt
- TST

-or-

- MT
+ TI
+ Sa/Wt
+ TST

Table 28

Analysis of Correlation Between
Combined Factors and TST

No.	MT	TI	Sa/Wt	TST	Analysis
1	-	-	-	+	MT dom.
2	+	+	o	-	MT dom.
3	+	+	+	-	MT dom.
4	+	0	-	-	*
5	+	+	-	+	TI dom.
6	o	-	-	+	?
7	+	+	o	+	TI dom.
8	+	-	-	+	?
9	+	-	o	-	*
10	-	+	o	+	*
11	+	+	+	-	MT dom.
12	+	-	+	-	MT & TI dom.
13	-	o	+	+	*
14	-	o	+	+	*
15	-	-	-	+	MT dom.
16	-	o	-	+	MT dom.
17	+	o	-	-	*
18	-	o	+	+	*
19	+	+	+	-	MT dom.
20	+	+	+	-	MT dom.
21	-	+	o	+	*
22	+	+	o	+	TI dom.
23	+	-	o	+	?
24	-	o	+	+	*
25	-	-	+	+	MT & Sa/Wt dom.
26	+	-	+	-	MT & TI dom.
27	+	-	o	-	*
28	-	-	+	+	MT & Sa/Wt dom.
29	+	-	o	-	*
30	+	o	-	-	*

APPENDIX L

CORRELATION BETWEEN EXTRANEOUS VARIABLES AND 2 HT

KEY TO TABLE 29

+ = greater than average

= = less than average

o = average

<u>averages</u>:

MT = 98.1 degrees

TI = 3 minutes

Sa/Wt = .028 square meters

2HT = 98.9 degrees

<u>analysis</u>:

* = + MT
- TI
- Sa/Wt
+ 2HT

-or-

- MT
+ TI
+ Sa/Wt
- 2HT

Table 29

Analysis of Correlation Between Combined Factors and 2HT

No.	MT	TI	Sa/Wt	2HT	Analysis
1	-	-	-	+	* s MT
2	+	+	o	+	MT dom.
3	+	+	+	+	MT dom.
4	+	o	-	+	*
5	+	+	-	-	TI dom.
6	o	-	-	-	?
7	+	+	o	-	* s MT
8	+	-	-	+	*
9	+	-	o	+	*
10	-	+	o	-	*
11	+	+	+	-	* s MT
12	+	-	+	+	TI dom.
13	-	o	+	+	?
14	-	o	+	-	*
15	-	-	-	+	* s MT
16	-	o	-	-	MT dom.
17	+	o	-	+	*
18	-	o	+	-	*
19	+	+	+	+	MT dom.
20	+	+	+	-	* s MT
21	-	+	o	-	*
22	+	+	o	-	* s MT
23	+	0	o	+	*
24	-	o	+	-	*
25	-	-	+	-	Sa/Wt dom.
26	+	-	+	+	TI dom.
27	+	-	o	+	*
28	-	-	+	-	Sa/Wt dom.
29	+	-	o	+	MT dom.
30	+	o	-	+	*