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TEMPERATURE RECORDINGS IN NEONATES

Linda Marie Hestvik

School of Nursing
Virginia Commonwealth University

This is to certify that the thesis prepared by Linda M. Hestvik entitled "Temperature Recordings in Neonates" has been approved by her committee as satisfactory completion of the thesis requirement for the degree of Master of Science.

[redacted]
Director of Thesis

[redacted]
Committee Member

[redacted]
Committee Member

[redacted]
School Director of Graduate Study

[redacted]
Department Chairman or Representative

[redacted]
School D

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By

Linda Marie Hestvik
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Director: Dr. Ethelyn Exley
Associate Professor
Medical-Surgical Nursing

Virginia Commonwealth University
Richmond, Virginia
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Chapter 1

THE PROBLEM

Introduction

Temperature measurement is an important index in the determination of a neonate's health status. Such a measurement provides information about the neonate's ability to adapt and survive amidst an ever-changing environment during the first days of life.

This study of neonatal temperature recordings was based primarily on two previously published investigations. In 1966, Nichols and others conducted a study to determine thermometer placement times in three commonly used body sites. In 1974, Eoff and others researched the relationships between neonatal rectal and axillary temperatures. The objective of this investigation is to provide further support for the findings in these sites.

Specifically, temperature measurements are a reflection of the maintenance of the neonate's body or core temperature in major organs and blood vessels (Adamsons, 1966; Erickson and Storlie, 1973; Guyton, 1981, p. 886). The body temperature is relatively constant (plus or minus one degree Fahrenheit) in neonates except at times of injury or illness. Such a constancy is maintained through peripheral and hypothalamic pre-optic receptors which transmit information to the posterior hypothalamus. The posterior hypothalamus regulates the body temperature by influencing the constant process of heat loss and heat gain in the body (Guyton, 1981, p. 886). The neonate looses heat through the skin by vasodilatation and sweat production via radiation, conduction, convection, and evaporation (Guyton, 1981, p. 888; Scopes, 1975, p. 101; Smith and Nelson, 1976, p. 373; Stern, 1978). Heat production is accomplished through peripheral vasoconstriction, postural changes, and chemical thermogenesis (Lutz and Perlstein, 1971; Smith and Nelson, 1976, p. 384; Guyton, 1981, p. 892).

Body orifices and skin folds in the neonate provide access for indirect measurements of body temperature. Direct measurement at the tympanic membrane and esophagus are not used routinely because the sites are not readily accessible. The rectal and sublingual orifices provide information about core blood temperature through their proximities to major arteries (Scopes, 1975, p. 105; Zuidema, 1977). The skin fold of the axilla also adequately reflects core temperature (Frank and Brown, 1978; Buntain et al., 1977) in a constant environment. Skin temperature is a highly indirect measurement because it is subject to internal heat dissipation and external environmental influences (Scopes, 1975, p. 105).

In nursing practice today, it is the responsibility of the nurse to assess the thermoregulatory status of the neonate (Blainey, 1974). The physical assessment of the neonate is comprised of two components--tactile and visual (Washington, 1978). The nurse palpates the skin, especially the hands and feet, to determine its warmth or coolness. The skin is also touched to detect the presence or absence of moisture. The neonate's skin color, posture, and muscle tone are directly observed (Blainey, 1974; Washington, 1978). The physical assessment assists the nurse in promoting neonatal thermoregulation balance.

The environmental components of the neonate's surroundings are also assessed by the nurse. The newborn nursery's room temperature and relative humidity are noted. The nurse assesses the movement of air in the room, the location of the basinette, and the clothing covering the neonate. The environmental examination explores means by which the nurse can promote neonatal heat loss or gain in the environment (Blainey, 1974; Washington, 1978).

Although overt observations assist the nurse, subtle changes in the neonate's body temperature need to be documented during the assessment (Blainey, 1974). A clinical glass thermometer is used to record such changes through the rectal or axillary sites (Nalpeka, 1976; Marlow, 1977; Spitz and Sweetwood, 1978; Nelson, 1979; Capobianco, 1980). Serial recordings of neonatal temperatures with a thermometer are especially useful in documenting the normalcy of a single temperature (Lutz and Perlstein, 1971).

The use of the rectal and axillary sites for temperature determination have their advantages and disadvantages. The rectum is considered to be the most scientifically accurate site (Erickson and Storlie, 1973; Buntain et al., 1977; Spitz and Sweetwood, 1978). Rectal thermometers are especially useful for the screening of congenital anamolies (VanLeeuwen and Glenn, 1968). However, the risk of rectal perforation with the thermometer is present (Fonkalsrud and Clatworthy, 1965; Frank and Brown, 1978; Merenstein, 1970; Scopes, 1975; Nalpeka, 1976; Buntain et al., 1977). Cross contamination from repeated insertions is also possible (Scopes, 1975). Unnecessary rectal stimulation could produce excessive fluid and caloric loss through stooling (Nalpeka, 1976). The axillary site, although not as accurate as the rectum (Erickson and Storlie, 1973), is an accessible and safe site (Fonkalsrud and Clatworthy, 1965; Blainey, 1974).

The duration for temperature recordings is unclear in current pediatric nursing literature. A recent nursing article stated that rectal thermometers required one to three minutes to register, and axillary recordings required 10 minutes for registration (Reynolds, 1978). Another article on neonatal thermoregulatory assessment recommended three minutes for an axillary thermometer to register (Capobianco, 1980). One pediatric text did not mention any time limit for rectal recordings, but advocated allowing five minutes for an axillary thermometer to register (Marlow, 1977). A patient and family education book recommended three minutes for a rectal thermometer to register (McCormick and Gilson-Parkevich, 1979). Another pediatric text did not state a specific length of time for any temperature determination (Waechter and Blake, 1976).

Studies concerning placement times for clinical thermometers have been made. Nichols and others (1966) recommended two minutes for rectal thermometers to register a temperature. In another investigation, it was found that four minutes for such a registration was necessary. Loudon (1957) recommended that five minutes was sufficient for temperature registration with axillary thermometers. Nichols and Glor (1968b) stated that eight minutes was needed for axillary thermometers to register temperatures. Oral thermometer placement time for temperature registration was found to vary from three minutes (Loudon, 1957) to 10 minutes (Nichols, 1968).

Gender and its influence on temperature determinations has been investigated. A majority of the research revealed that there was no significant difference between males and females in thermometer registration times (Torrance, 1968; Nichols, Kucha, and Mahoney, 1972; Erickson, 1976).

Differences between temperature recordings and the subject's race have been studied. One study reported that there was no difference (Miller and Oliver, 1966), and another study indicated that there were differences in temperature recordings between white and black infants (Whitner and Thompson, 1970).

Environmental influences and technique of thermometer placement have been investigated. Independent variables, such as iced water ingestion and smoking, influence oral thermometer temperature registration (Woodman, Parry, and Simms, 1967). The administration of oxygen by nasal cannula did not affect oral thermometer registration in Graas's (1974) study. Erickson (1976) found that the exact location of the oral thermometer during the temperature recording process influenced the thermometer's registration. In 1980, Erickson concluded that the same technique must accompany the use of the same thermometer when assessing the patient's temperature.

Research in the field of neonatal thermoregulation utilizing temperature determinations in different body sites is quite extensive. Numerous investigations into evaporative heat loss in neonates have been made (Miller and Oliver, 1966; Phillips, 1974; Smales and Kime, 1978; Britton, 1980). Neonatal chemical thermogenesis and metabolic rates have been researched (Silverman et al., 1964; Rylander, 1972; Perlstein et al., 1974; Dufour, Little, and Thomas, 1976).

The relationship between axillary and rectal temperature recordings is still inconclusive. In nursing education, students are generally taught that there is a plus or minus one degree Farenheit difference between rectal and oral, and oral and axillary recordings (DuGas, 1977). Current studies have shown that such a relationship could be incorrect (Nichols et al., 1966; Eoff et al., 1974; Coyer, 1980).

Because of the lack of clarity concerning the relationship between axillary and rectal temperatures and the duration of such determinations, this study of temperature recordings in neonates was undertaken. It is, therefore, the purpose of this study to provide empirical evidence to answer the following questions:

1. What is the length of time required for glass thermometers to register the temperature in neonates at the rectal and axillary sites?
2. Do significant differences exist between simultaneous axillary and rectal temperature recordings in neonates?
3. What is the relationship between axillary and rectal temperature recordings at specified time intervals in neonates?

Nursing Theory

In 1964, Sister Callista Roy proposed a conceptual model for nursing. In the years that followed, the model was developed into a framework for nursing practice, education, and research. In current practice today, the model has been "fully developed and operationalized" (p. 135) into general use (Riehl and Roy, 1974).

The basis of Roy's (1970) model is man because he is the recepient of nursing care. Man is a biopsychosocial being, who is continually interacting with an ever-changing environment. Coping with the environment is achieved by man through the utilization of both innate and acquired mechanisms. These mechanisms are social, psychologic, and biologic in nature (Roy, 1970; Roy, 1971; Riehl and Roy, 1974). An example of an innate, biological mechanism would be pupil dilatation in a dark room. An example of an acquired (or learned), social mechanism would be someone who smokes cigarettes only at parties. Through these mechanisms, man attempts to respond to the ever-changing environment (Roy, 1970).

Man, according to Roy (1970), is present on a health-illness continuum. His position on the continuum varies with any particular time or situation. He must respond to a variety of stimuli wherever he is located on the continuum.

When man responds to stimuli from the environment, he is using the process of adaptation. "Adaptation decreases the responses necessary to cope with the predominant stimulation and therefore increases sensitivity to complementary stimuli" (Roy, 1970, p. 43). The specific adaptation response depends upon the adaptation level of the organism. Man's adaptation level is determined by the total effect of three types of stimuli: "1. focal stimuli, or stimuli immediately confronting the person, 2. contextual stimuli, or all other stimuli present, and 3. residual stimuli, such as beliefs, attitudes, or traits which have an indeterminate effect on the present situation" (Riehl and Roy, 1974, p. 137). Thus, for example, the presentation of a gun, the absence of other people around, and a person's previous experience with a robbery all influence his adaptation to a robbery attempt.

The adaptation level of man has within it a zone or a range of stimulation that will lead to a positive response. If the stimulus is outside of the range, a positive response will not occur. However, if the stimulus is within the zone, then a positive response can be made by the person (Roy, 1970; Riehl and Roy, 1974). Thus, a person raised in a crime-free town has a narrow range of adaptability to a robbery attempt, while someone raised in a crime-laden city has a wider range of adaptability.

Roy (1971) conceptualized man as having four modes of adaptation. A mode is "a way or method of doing or acting"(Riehl and Roy, 1974, p. 138). The first mode of adaptation is man's physiological needs. Man must balance his needs pertaining to oxygen, fluids and electrolytes, nutrition, body temperature, activity and sleep, circulation, digestion, and elimination. Man's self-concept, i.e. the manner in which man's self interacts with the environment, is the second mode. The third mode of adaptation is through man's role mastery or role function. Man adapts his role to his varying positions in society, i.e., teacher to his students, father to his son, etc. Interdependence is the fourth mode of adaptation. Man's interactions or relations with others in the environment are included in this mode (Roy, 1971; Riehl and Roy, 1974).

The goal of nursing, according to Roy, is to promote "man's adaptation in the four adaptative modes" (Riehl and Roy, 1974, p. 139). This goal is accomplished through nursing assessment and intervention. Nursing assessment includes determining man's position on the health-illness continuum, evaluating man's level of adaptation, and determining the environmental stimuli reacting with the man. Nursing intervention includes "changing the response potential by bringing the stimuli within the zone where a positive response is possible" (Roy, 1970, p. 43). The nurse accomplishes this by altering the influencing factors (i.e., focal, contextual, and/or residual stimuli) (Roy, 1970; Roy, 1971; Riehl and Roy, 1974).

In specific application of Roy's conceptual framework to this research study, the neonate is a biopsychosocial being, who is in constant interaction with the ever-changing environment. The neonate copes with the environment through innate, e.g., chemical thermogenesis and vasodilatation (Lutz and Perlstein, 1971) and acquired mechanisms, e.g., crying to signal the nurse when feeling too warm (Roy, 1970; Riehl and Roy, 1974).

Adaptation to the environment depends upon the neonate's specific adaptation level. The adaptation level is determined by the sum effects of focal, contextual, and residual stimuli. Thus, for example, the temperature of the newborn nursery, the relative humidity present, and the neonate's previous exposure to temperature extremes all influence the adaptation response to changing temperatures (Roy, 1970; Riehl and Roy, 1974).

The neonate has four modes of adaptation (Roy, 1971), and the mode of physiological needs is of particular importance. The neonate must balance his needs pertaining to body functioning, especially that of body temperature. Body temperature reflects the balance between heat production and heat loss in the body. The clinical glass thermometer is the usual method of determining body temperature. The average temperature in neonates is 36.5 to 37.5 degrees Celsius (Porth and Kaylor, 1978). The thermometer may be placed in the rectum, axilla, or mouth. "The axillary reading is one-half degree (Fahrenheit) lower than the mouth reading, the rectal reading one degree (Fahrenheit) higher. The thermometer should be left in place until a constant temperature reading is obtained" (Poush, 1976, p. 127).

The goal of nursing is to promote "adaptation in the four adaptive modes" (Riehl and Roy, 1974, p. 139), particularly of the mode of physiological needs, including thermoregulation. This goal is accomplished through nursing assessment and intervention. Nursing assessment includes determining the infant's position on the health-illness continuum, evaluating the neonate's level of adaptation via a clinical glass thermometer and direct observation, and determining the environmental stimuli reacting with the neonate. Nursing intervention includes altering the focal, contextual, and/or residual stimuli (e.g., increasing or decreasing the environmental temperature) (Riehl and Roy, 1974).

In order to promote the goal of nursing, and specifically thermoregulatory adaptation in the neonate, the implementation of the glass thermometer as an assessment tool must be investigated. The purpose of this study is to test Roy's hypothesis that axillary recordings are one-half degree Fahrenheit lower than oral recordings, and that rectal recordings are one degree Fahrenheit higher than oral recordings (Poush, 1976). The length of time that the thermometer should be left in place until a constant reading is obtained will also be investigated. Once the relationship between the axillary and rectal sites is determined and the time for such determinations are ascertained, then the nurse can promote an adaptive physiological state in the neonate.

Neonatal Thermoregulation Theory

Body temperature is a measurement of the balance between heat production and heat loss in the neonate (Lutz and Perlstein, 1971). Neonates continually produce heat from metabolic processes and simultaneously loose heat into the environment. When the rate of heat production is equivalent to the amount of heat loss, then the neonate is in a state of thermal balance (Guyton, 1981, p. 887).

Temperature in the neonate is regulated primarily through peripheral receptors (Adamsons and Towell, 1965; Motil and Blackburn, 1973; Porth and Kaylor, 1978). The receptors are located in the skin (e.g., parts of the face and upper respiratory tract) (Motil and Blackburn, 1973), abdomen, spinal cord, and other internal body structures (Guyton, 1981, p. 891). The role of the peripheral receptors is to monitor coolness and cold in the environment (Motil and Blackburn, 1973; Guyton, 1981, p. 891). The peripheral receptors respond specifically to differences in the net exchange of thermal energy between the environment and the skin (Adamsons and Towell, 1965).

Hypothalamic thermal receptors seem to play a secondary role in neonatal thermoregulation (Adamsons, 1965; Heim, 1971). Heat-sensitive neurons are located in the pre-optic region of the hypothalamus. Cold-sensitive neurons, which play a minute role, are located in other parts of the hypothalamus, the septum, and the mid-brain (Guyton, 1981, p. 890). The degree of activity of these receptors determines the initiation of hypothalamic induced thermoregulatory responses.

Both peripheral and pre-optic receptors transmit information of the neonate's thermoregulatory status to the posterior hypothalamus where the receptor signals are integrated. The results of the integration produces either heat producing or heat loosing responses in the neonate's body (Guyton, 1981, p. 891).

Neonates have the innate ability to maintain their body temperature (Brück, 1961) when present in a neutral thermal environment. Hey and Katz (1970) described this environment as "any set of conditions which allows body temperature to remain normal while oxygen consumption and heat production are minimal and effectively matched by heat loss" (p. 328). The environmental thermal range that promotes neonatal maintenance is between 32 to 34 degrees Celsius (Brück, 1961) in an environment of 50 percent relative humidity. This produces a neonatal rectal temperature of 36.5 to 37.5 degrees Celsius (Hey and Katz, 1970). If the environmental temperature should fall above or below the neonate's thermal range, or if the temperature was close to the range's boundaries, thermoregulatory processes would be initiated (Scopes, 1970).

Heat dissipation into the environment is accomplished by the neonate utilizing several processes including radiation, conduction, convection, and evaporation (Motil and Blackburn, 1973; Scopes, 1975, p. 101; Oliver, 1975; Smith and Nelson, 1976, p. 373; Stern, 1978; Guyton, 1981, p. 888). Radiation is a process in which infrared heat rays are lost from the neonate to the surrounding environment (i.e., to the walls and objects) (Guyton, 1981, p. 888).

Radiation accounts for approximately 66 percent of total heat loss in the neonate (Motil and Blackburn, 1973). Conduction, the process by which heat is lost from the body through direct contact between the skin and inanimate objects (Guyton, 1981, p. 888), accounts for less than 5 percent of total heat loss in the neonate (Motil and Blackburn, 1973). Convection is described as minute heat exchange between the neonate and his environment by movement of new, unheated air around the body (Smith and Nelson, 1976, p. 373; Guyton, 1981, p. 888). Evaporation is the loss of heat through water loss from the lung and body surface to the environment (Guyton, 1981, p. 888). Evaporation is dependent upon the relative humidity and alveolar ventilation (Oliver, 1975) and it accounts for 25 percent of neonatal heat loss (Scopes, 1975).

The neonate initiates heat loosing processes (i.e., radiation, conduction, etc.) through vasodilatation, especially through the hands and feet, and inhibition of the vasoconstrictive centers in the posterior hypothalamus (Guyton, 1981, pp. 891-92). These actions lead to increased heat loss via convection and radiation (Sinclair, 1972; Smith and Nelson, 1976, p. 381). Sweating occurs, when the rectal temperature of the neonate is greater than 37.7 degrees Celsius (Sinclair, 1972; Smith and Nelson, 1976, p. 381), and increases evaporative heat loss from the body (Scopes, 1970; Guyton, 1981, pp. 891-92).

Body heat loss is greater in neonates than adults. This difference is due to body weight ratio, abdominal convexity, and decreased skin and subcutaneous thickness in the neonates (Adamsons and Towell, 1965; Bennett, Patel, and Grundy, 1977; Kanto and Calvert, 1977).

Heat conservation and production in the neonate is achieved through several means. Heat conservation occurs through neonatal peripheral cutaneous vasoconstriction (Scopes, 1970; Lutz and Perlstein, 1971; Sinclair, 1972; Smith and Nelson, 1976, p. 384; Kanto and Calvert, 1977; Guyton, 1981, p. 892) and by postural changes, i.e.,increased flexion of the extremities (to decrease the surface area) (Lutz and Perlstein, 1971; Smith and Nelson, 1976, p. 373). Heat production is enhanced by an increase in metabolic rate via chemical or nonshivering thermogenesis (Scopes, 1970; Sinclair, 1972; Smith and Nelson, 1976, p. 384; Kanto and Calvert, 1977; Stern, 1978). The source of the thermogenesis is suggested to be neonatal brown fat (Hull, 1966; Nalepka, 1976; Bennett, Patel, and Grundy, 1977; Guyton, 1981, p. 892) which is located in the interscapular space (Nalepka, 1976; Guyton, 1981, p. 892), the nape of the neck (Silverman, Sinclair, and Agate, 1964; Nalepka, 1976), perirenal and thoracic regions. These highly vascular, mitochrondria rich regions are stimulated by the sympathetic nervous system to release caloric energy and heat (Smith and Nelson, 1976, p. 389; Kanto and Calvert, 1977; Stern, 1978). Chemical thermogenesis can increase the rate of neonatal heat production by as much as 100 percent (Guyton, 1981, p. 892).

The neonate is unable to maintain heat production and conservation for prolonged periods of time. Hypothermia, the process of excessive heat loss or cooling (Washington, 1978), can readily occur. Hypoglycemia, hypoxemia, kernicterus, cardiac irritability, and abnormal reactions to drugs are responses seen in neonates who are cold stressed (Gandy et al., 1964; Scopes, 1975, p. 105; Nalepka, 1976; Kanto and Calvert, 1977; Bennett, Patel, and Grundy, 1977; Stern, 1978).

Hyperthermia, from prolonged heat stress, may also occur in the neonate (Scopes, 1975; Washington, 1978). This could be due to rapid rewarming of the hypothermic neonate, or to excessive exposure to high environmental temperatures (e.g., from an isolette). Seizures, heat-induced apnea, dehydration, and scalding of the skin may result (Scopes, 1975, p. 105; Kanto and Calvert, 1977; Stern, 1978; Washington, 1978).

In summary, body temperature of the neonate is maintained through heat loss and heat gain via peripheral and pre-optic receptor input into the thermoregulatory center of the brain (Guyton, 1981, p. 886). Heat dissipation or production is reflected by the blood in the major blood vessels. Major vessels have indirect branches to three specific tissue regions--axillary, sublingual, and rectal sites. However, the exact thermal relationship of these sites to each other is in need of further investigative support (Nichols et al., 1966; Eoff et al., 1974). Rectal and axillary temperature recordings assist in determining the degree of thermoregulatory balance in the neonate. This study will attempt to support the existence of a positive relationship between these two recordings.

Hypotheses

Based on the conceptual framework of this study, the researcher tested whether:

1. Significant differences exist between simultaneous axillary and rectal temperature recordings in neonates.

2. There is a direct and positive correlation between axillary and rectal temperature recordings at specified time intervals in neonates.

Definition of Terms

Neonate--a full-term human, 38 to 42 weeks gestation, reportedly in good health, with a weight greater than five and a half pounds, and over 24 hours of age and less than one month.

Rectal temperature--a measurement of the neonate's body temperature via the rectum with a glass thermometer.

Axillary temperature--a measurement of the neonate's body temperature via the left axilla with a glass thermometer.

Maximum temperature--"The highest reading of a thermometer during a 12 minute period" (Nichols et al., 1966, p. 307).

Optimum temperature--"The maximum temperature minus 0.2 degrees Fahrenheit" (Nichols et al., 1966, p. 307).

Maximum placement time--"That time required for 90 percent of the subject's thermometers to reach their maximum readings" (Nichols et al., 1966, p. 307).

Optimum placement time--"That necessary for 90 percent of the subject's thermometers to reach their maximum readings minus 0.2 degrees Fahrenheit" (Nichols et al., 1966, p. 307).

Assumptions

This study depended on the following assumptions:

1. The glass thermometers used for the temperature measurements were accurate.
2. The rectal and axillary placement sites were consistent (i.e., insertion of the thermometer three centimeters) throughout the recordings.
3. The second hand on the watch was accurate; the same watch was used in all determinations.
4. All infants were exposed to the environment in the same manner--shirt open (with arms in the sleeves) and a disposable diaper under the buttocks.
5. Temperature readings made by the nurse investigator were correct.
6. The subject's gender and race did not influence the observed body temperature.

Limitations

The limitations of this study were:

1. Temperature recordings were made in a thermally uncontrolled environment.

2. Subjects were assumed to have no thermal regulating difficulties.

3. The same nurse will take the temperature readings and record the results.

Delimitations

The delimitations of this study were:

1. Study was limited to 30 neonates in the newborn nursery of an urban southeastern teaching hospital.

2. The subjects were normal, healthy neonates weighing greater than five and a half pounds and over 24 hours of age.

3. Only axillary and rectal sites were used for temperature determinations.

4. Neonates who had participated in hospital procedures within one hour of testing were omitted (e.g., circumcision).

5. Temperature was recorded to the nearest tenth of a degree Fahrenheit.

Chapter 2

REVIEW OF THE LITERATURE

Introduction

This chapter contains a review of the literature from the fields of nursing, medicine, anthropology, and physiology as related to various aspects of this study. The first section provides information on thermometer placement time and factors which influenced the placement. The second section discusses temperature differences in various body sites. The final section introduces current research on factors influencing thermoregulation in the neonate.

While this review of the literature was not exhaustive, an effort was made to include the most current and well documented research.

Thermometer Placement Time

Rectal Thermometer Placement Time

The first major study in the field of thermometer placement time was performed by Nichols and others (1966). They investigated placement time for rectal thermometers. Sixty subjects, aged 18 to 50 years, had simultaneous 12 minute measurements of rectal, axillary, and oral temperatures. Maximum placement time, or "the time required for 90 percent of the subjects' thermometers to reach . . . the highest reading during a 12 minute period" (Nichols et al., 1966, p. 307) in the rectum, with room temperature ranging from 70 to 86 degrees Fahrenheit, was four minutes. Optimum placement time or "the time necessary for 90 percent of the subjects' thermometers to reach their maximum readings minus 0.2 degrees Fahrenheit" (p. 307) in the rectum, was two minutes. The investigators concluded that two minutes was adequate for rectal thermometers to register temperatures. Further research was recommended to include larger sample sizes to confirm their findings, to correlate placement time with age and gender, and to explore placement time in febrile subjects.

Nichols and Verhonick (1967) continued the study of maximum and optimum placement time for rectal thermometers with the subjects in two different environmental temperatures. Two groups of 30 males, aged 18 to 31 years, were placed either in a room of 65 degrees Fahrenheit or 95 degrees Fahrenheit, both with a 50 percent relative humidity. The findings of this experimental study were that four minutes maximum and two minutes optimum placement time were required in the warm room, but four minutes maximum and three minutes optimum placement time were required for rectal thermometers to register in the cool room. It was concluded that a longer placement time was necessary for thermometers to register in subjects in cool rooms.

Nichols and Glor (1968b) investigated rectal temperature taking time in Vietnam. Twenty-one females and six males (22 to 48 years old), in a room temperature ranging from 83 to 89 degrees Fahrenheit, were studied. An optimum placement time of one minute and a maximum time of two minutes were declared; results indicated that a shorter placement time for rectal thermometers to register was necessary in warm environments.

A replication of rectal thermometer placement studies was conducted by Nichols and Glor (1968). The optimum placement time was two minutes and the maximum was three minutes for rectal thermometers to register the subject's temperatures. Data from 146 afebrile subjects, in a room temperature of 80 to 91 degrees Fahrenheit, were similar to their previous studies.

Torrance (1968) reported that three minutes was required for rectal temperature determinations. One hundred and twenty premature infants, with weights greater than 1,500 grams, had temperature readings taken and recorded. One hundred percent of the rectal recordings had stabilized in the rectal thermometer by the third minute. These results were applicable only to temperatures taken in a "modern, air-conditioned premature suite" (p. 313).

In 1972, Nichols, Kucha, and Mahoney investigated 50 adult febrile subjects, 25 male and 25 female in room temperatures ranging from 72 to 82 degrees Fahrenheit. Six one-minute rectal temperature readings revealed two minutes as the optimum and three minutes as the maximum placement time for rectal thermometers to register the subjects' temperatures. The investigators concluded that two minutes was a satisfactory length of time to allow rectal temperatures to register in a thermometer.

Nichols and others, later in 1972, measured rectal temperatures of febrile children with rectal temperatures greater than 101 degrees Fahrenheit, in an environmental temperature of 70 to 82 degrees Fahrenheit. Forty children, aged one to six years, had eight rectal readings at one minute intervals. The maximum placement time was seven minutes, and the optimum was four minutes for the rectal thermometer to register the subject's temperatures. This would indicate a longer placement time for rectal thermometers in young children when compared to the adult studies.

Nichols (1972) did a secondary data analysis of five investigations of rectal thermometer placement time (Nichols et al., 1966; Nichols and Verhonick, 1967; Nichols and Glor, 1968b; Nichols and Glor, 1968; Nichols, Kucha, and Mahoney, 1972). The following guidelines were recommended: two minutes for all rectal thermometers to be placed for temperature registration in adults with room temperatures of 72 degrees Fahrenheit or greater, and three minutes if the room is less than 72 degrees Fahrenheit. These recommendations indicate that room temperature influences rectal thermometer placement time.

Axillary Thermometer Placement Time

Loudon (1957) studied axillary temperatures in 25 afebrile children, aged three to 15 years. Five recordings, at one minute intervals, were obtained. The results supported Loudon's assumption that five minutes was adequate for thermometers placed in the axilla to register temperatures. After three minutes, only 13 of 25 thermometers had registered the temperatures. At the end of four minutes, all but one of the axillary thermometers had stabilized. The results of this study may have led to an unreliable conclusion because time past five minutes was not investigated. Further research was needed.

Nichols and others (1966) determined maximum and optimum placement time for axillary thermometers in adult afebrile subjects. After five minutes, only 18 percent of the thermometers had registered the subject's maximum temperature. Sixty-eight percent of the subject's thermometers had reached their maximum temperature at 10 minutes. And after 11 minutes, 90 percent of the subject's thermometers had reached their maximum temperatures. The optimum axillary placement time was nine minutes for thermometers to reach their maximum readings minus 0.2 degrees Fahrenheit. The investigators recommended further research.

Nichols and Glor's (1968b) study stated that the optimum and maximum placement time for axillary thermometers to register temperature in the adult subjects was eight minutes and 10 minutes respectively.

Torrance (1968) reported that in premature infants, with weights greater than 1,500 grams, only 2 percent of the axillary thermometer registrations had stabilized at three minutes. At four minutes, 95 percent of the subject's thermometers had reached their maximum axillary temperature. The time needed for axillary thermometers to register in premature infants coincides with that of children (Loudon, 1957), i.e., four minutes is necessary for thermometers to register. This information suggested that perhaps the environment temperatures were similar, although the environmental temperature in both studies was not reported.

Oral Thermometer Placement Time

Loudon (1957) investigated oral temperatures in 25 children aged three to 15 years. The results indicated that three minutes was sufficient time for 24 of 25 subject's oral thermometers to register accurately the temperatures. However, information regarding criteria for subject selection (i.e., if limitations on ingesting hot or cold liquids were made, or if baseline afebrile oral temperatures were obtained, etc.) was not reported.

Twelve one-minute intervals of oral temperature recordings were made by Nichols and others (1966). The optimum placement time for 90 percent of the afebrile adult's thermometers to reach their maximum readings minus 0.2 degrees Fahrenheit was seven minutes. The maximum placement time for 90 percent of the subject's thermometers to reach their highest recording was 10 minutes. These findings did not support placement times recommended by the investigators' literature review.

Nichols and Verhonick (1967) studied the optimum and maximum placement times for the subject's oral thermometers to register their highest readings in a room of 65 degrees Fahrenheit, with a 50 percent relative humidity. Sixty men, 18 to 31 years of age, had oral temperatures taken for 12 minutes. Results showed that 73 percent of the subject's thermometers reached their optimum temperature readings after five minutes, and 90 percent of the subject's thermometers attained their optimum temperature readings at seven minutes. Maximum placement time for the subject's thermometers to register was 11 minutes. The investigators recommended seven minutes as the thermometer placement time for oral thermometers to determine subject's temperatures. Data supported the premise that longer times are necessary for oral temperature determinations in cool environments.

In Vietnam, Nichols and Glor (1968b) found that in an environment of 83 to 89 degrees Fahrenheit the optimum and maximum placement time for oral thermometers was five minutes and six minutes, respectively. The findings supported a shorter placement time for thermometers when subjects are in warm environments.

Later in 1968, Verhonick and Nichols continued research on oral temperature determinations. In past studies, thermometers were inserted with a reading of

95 degrees Fahrenheit, and they were removed every minute for five seconds to read. An experimental study was performed to determine: (1) whether removal of the thermometer for five seconds every minute would influence the time for temperature registration; (2) the maximum and optimum placement times for oral thermometers to determine temperatures; and (3) if the pre-temperature thermometer mercury level (i.e., 95 degrees Fahrenheit versus 96 degrees Fahrenheit) would influence the temperature registration. The results showed no significant difference (p=.05) if the thermometer were removed intermittently or remained inserted. Optimum and maximum placement time was seven and 10 minutes, respectively, for thermometers to register in 60 adults. The difference was not significant (p=.05) in groups with either initial mercury reading. This information suggested that the investigators continue their current methods of study.

Nichols (1968) studied 40 healthy afebrile children, 20 male and 20 female, aged seven to 12 years, in an environmental temperature of 66.78 degrees Fahrenheit. Six readings at two minute intervals were made. Maximum and optimum placement time for the subject's thermometers to register was 12 and 10 minutes, respectively. However, since the readings were made every two minutes, the optimum and maximum thermometer placement time could have been reached between the intervals.

Nichols and others (1969) reported that the optimum oral placement time for thermometers to register in febrile adults was six minutes. The sample consisted of 50 febrile subjects with temperatures greater than 100 degrees Fahrenheit, who were 18 to 65 years of age. The investigators concluded that the three to five minute placement time for thermometers used in common practice was insufficient to reflect a patient's febrile temperature.

In 1971, 15 student nurses reported that to determine an oral temperature "at least four minutes" (p. 1139) was necessary for thermometers to be inserted into subjects. Five readings of oral temperatures at 30 seconds, one, two, three, and four minutes on three consecutive mornings were made. After a comparison of the results for each interval, the recommendation of four minutes for oral thermometers to be inserted into subjects was made. The results of this study should be viewed with caution because the term "at least" was inconclusive.

Nichols and others (1972) obtained recordings in 50 febrile children with temperatures greater than 100 degrees Fahrenheit. The maximum and optimum placement time for oral thermometers to register in the subjects was 11 minutes and seven minutes, respectively. The results supported placement time similar to that of adults.

Nichols and Kucha (1972) performed a secondary analysis of data pertaining to oral thermometer placement time (Nichols et al., 1966; Nichols and Verhonick, 1967;

Nichols and Glor, 1968b; Verhonick and Nichols, 1968; Nichols et al., 1969). They recommended that in room temperatures of 65 to 75 degrees Fahrenheit, eight minutes was the optimum placement time; in room temperatures of 76 to 86 degrees Fahrenheit, seven minutes was the optimum placement time for subject's thermometers to register. Such recommendations, based on room temperatures, warrant the inclusion of environmental temperatures in the reports of future studies.

Gender and Temperature Determinations

Differences in temperatures between males and females have been noted. Horvath, Menduke, and Piersol (1950) compared temperatures in 38 females, aged 19 to 35 years, and 16 males, aged 21 to 37 years. Mean morning rectal temperature in men was 98.2 degrees Fahrenheit and 98.6 degrees Fahrenheit in females. The 0.4 degrees Fahrenheit rectal temperature difference between the males and females was significant ($p=.01$). The mean difference between oral and rectal temperatures for males was 0.84 degrees Fahrenheit and for females was 0.76 degrees Fahrenheit. Based on this 0.08 degree Fahrenheit difference, the hypothesis of no real difference between oral and rectal readings for males and females was accepted (level of significance was not reported). A five minute thermometer placement time was used.

Nichols and others (1966) asserted that firm conclusions about temperature differences between males and females could not be made. Data from their study, which included 10 male and 50 female subjects, showed that females reached stable oral and rectal temperatures after longer thermometer placement time than males. Females required 72 seconds longer for their thermometers to register stable axillary temperatures. Additional research was recommended.

Torrance's (1968) study revealed that different times were not required for thermometers to register in male and female premature infants. Paired, calibrated glass thermometers with thermistor probes couple to telethermometers were used. Mean rectal thermometers in males required 2.55 plus or minus 1.43 minutes to register, and in females, 3.7 plus or minus .89 minutes were needed. The differences in temperatures between males and females was not significant ($p=.05$).

Nichols and others (1969) reported optimum placement time for oral thermometers in males and females. In room temperatures of 72 to 76 degrees Fahrenheit, identical results were found in 23 males and 11 females. However, in room temperatures of 78 to 84 degrees Fahrenheit, there were differences in placement time between two males and 14 females for thermometers to register. The differences may have been due to the limited sample size for the warmer room.

Nichols, Kucha, and Mahoney (1972) found that there was no difference in time required for optimal rectal thermometer registration in males and females.

Nichols (1968) concluded that time varies for oral thermometer placement in afebrile male and female children. Males required 10 minutes and females needed eight minutes for optimum temperature registration in oral thermometers. The variation may have been due to the use of two minute timed intervals for recording temperatures.

Nichols and others (1972) compared mean oral and rectal thermometer placement time in 17 male and 23 female children. There was no significant difference ($p < .6$) in mean oral time for males (4.4 minutes) and females (four minutes). However, mean rectal time was significant ($p < .01$) between males (1.8 minutes) and females (2.9 minutes). No satisfactory explanation for the differences was presented by the investigators.

Nichols and Kucha (1972) summarized their past studies on oral temperatures in 390 subjects. Two hundred and five males had an optimum placement time for thermometers to register of seven minutes, and 185 females had an optimum placement time of eight minutes. The differences between the sexes may be due to the different environmental conditions during the various studies.

Nichols (1972) summarized past investigations on rectal temperatures in 403 subjects. Optimum placement time in males and females was the same, i.e., two minutes, for thermometers to register temperatures.

Erickson (1976) found no differences between males and females with oral temperature recordings. Twenty-five males and 25 females, aged 20 to 81 years, had oral temperatures compared. Erickson concluded that a person's gender does not influence body temperature, even though a statistical analysis of the data was not performed.

Edwards, Belyavin, and Harrison's (1978) data analysis revealed no difference in temperatures between males and females during exercise or water immersion. The sample size consisted of 12 adult subjects.

Temperatures and Race

Differences between temperature recordings and the subject's race have been studied. Miller and Oliver (1966) found no appreciable difference between temperatures in Black and Caucasian infants. Torrance (1968) reported no significant difference ($p=.05$) in temperatures according to race. However, Whitner and Thompson (1970) found that Black infants had 0.5 degrees Fahrenheit lower body temperatures three to six hours after a bath. This difference was significant at $p<.01$ at three hours and $p<.05$ at six hours.

Effects of Independent Variables on Oral Temperatures

Verhonick and Werley (1963) studied the influence of independent variables, i.e., smoking, gum chewing, and hot and cold liquid ingestion on oral temperatures. Pretest and post-test temperatures were taken on both the control and experimental groups. Analyzed data revealed a significant influence of hot and cold liquid ingestion on oral temperatures (level of significance was not reported). Smoking and chewing gum did not affect oral temperatures. Further investigation was indicated because type of thermometer and placement time were not reported.

Woodman, Parry, and Simms (1967) investigated the local effects of smoking and drinking of cold liquids on oral temperatures. The sample consisted of 74 males, aged 18-52 years. Three groups, two experimental and one control, had pretest and post-test temperatures taken with standard glass thermometers for 15 minutes duration. Iced water ingestion had significant results ($p=.0005$) on oral temperatures. Changes were also produced by smoking ($p=.05$). The investigators concluded that drinking and smoking led to unreliable oral temperature determinations. These results contradict Verhonick and Werley's (1963) results on influences by smoking.

Forster, Adler, and Davis (1970) studied the effect of iced water ingestion on oral temperatures. Nineteen male subjects, 26 to 50 years of age, nine febrile and 10 afebrile, had temperatures monitored with a telethermometer thermistor probe five minutes before, and 15 minutes after a two minute ingestion of cold water. Results indicated that the water decreased the oral temperature by five and a half degrees Fahrenheit, and that its effect lasted for 15 minutes. There was no difference in response between febrile and afebrile patients (level of significance was not reported). The investigators recommended replication of their study which would include a larger sample size and further improvement of experimental technique.

Placement Sites for Oral Thermometers

Erickson (1976) studied oral temperature differences in three sublingual sites of febrile adults with their mouths opened or closed. Fifty subjects, aged 20 to 81 years, with oral temperatures greater than 100 degrees Fahrenheit, had temperatures taken with an electronic thermometer in the left and right posterior sublingual areas, and in front of the tongue. Results showed that the temperatures were significantly higher ($p < .01$) in the two posterior pockets than in the front area. The temperature difference between the left and right posterior pockets was of neither clinical nor statistical significance ($p > .05$). Whether the mouth was opened or closed made no difference. This information suggested that the exact area of thermometer placement within a site influences temperature determination.

Erickson (1980) investigated oral temperature differences in relation to the thermometer used. Fifty afebrile and 50 febrile subjects were studied to examine the differences between standard glass and electronic thermometers in three sublingual sites. Glass thermometers were placed for eight minutes in the front of the tongue, in the left and right posterior sublingual pockets. Measurements were repeated using the electronic thermometer. Results supported Erickson's (1976) previous study in that temperatures in the sublingual pockets were significantly higher ($p < .01$) than in the front area using the electronic thermometer. However, results using the mercury thermometer were not statistically significant among the three sites. Values between the two instruments differ statistically during the study ($p < .01$). The investigators concluded that interchangeable use of thermometers could lead to error in the assessment of a patient's temperature.

Graas (1974) performed an experimental study on the effects of oxygen administration on oral temperature administration. Nine females, aged 21 to 24 years, had simultaneous oral and rectal temperatures taken, for five minutes duration, before and after administration of oxygen per nasal cannula at three liters per minute. The rectal recordings served as control for the study. It was found that changes in oral temperatures were insignificant ($p = .05$) after oxygen was given. The investigator asserted that the limited number of subjects may have led to an unreliable conclusion. The five minutes duration for the oral temperature may have influenced the results.

Temperature Differences in Various Body Sites

Differences Between Oral and Rectal Temperatures

Oral and rectal temperature differences were investigated by Cranston, Gerbrandy, and Snell (1954). Ninety-three experiments, on 40 seated adult subjects, over a 10 minute period, were made. Rectal temperatures were 0.35 plus or minus 0.01 degrees Celsius higher than oral (sublingual) readings at a room temperature of 19 to 24 degrees Celsius using a thermocoupler. It was not reported whether these differences were statistically significant.

Strydom and others (1956) studied oral temperatures of mine workers in an attempt to find a substitute for rectal recordings. Two hundred and twenty-nine underground laborers, in an environmental temperature of 82 to 93 degrees Fahrenheit, had simultaneous oral and rectal recordings made for three minutes duration. Temperatures ranged from 98.5 to 104.4 degrees Fahrenheit orally, and from 99.4 to 106.2 degrees Fahrenheit rectally. The mean difference was 1.22 plus or minus 0.64 degrees Fahrenheit. The correlation between the two sites was high (r=.83). The investigators decided that 101 degrees Fahrenheit by mouth equalled 103 degrees Fahrenheit per rectum. Although statistical analysis was not reported, the three minutes used for the thermometer placement may have led to an unreliable conclusion.

Sellars and Yoder (1961) used an experimental design to study 1,431 pairs of oral and rectal temperature recordings from 10 males. Simultaneous oral and rectal temperatures were taken for three minutes duration after subjects were exposed to varying exercises and environmental temperatures. The mean oral temperature reading was 97.6 degrees Fahrenheit, and the mean rectal temperature was 99.0 degrees Fahrenheit. The two sites differed from zero to five degrees Fahrenheit. Thirty-four percent of the subjects showed a one to one and a half degrees Fahrenheit difference. Only 15 percent of the recordings revealed exactly a one degree Fahrenheit difference. This led the investigators to question the assumption that rectal recordings are one degree Fahrenheit higher than oral recordings. The effects of using three minutes for the thermometer placement time were not investigated.

George (1965) observed oral and rectal temperature differences in 60 patients. The researcher reported that the two sites show a variation of zero to two degrees Fahrenheit. This conclusion may be unreliable because purposes, methodology, and statistical analysis for the study were not reported.

A zero to 2.8 degrees Fahrenheit difference between rectal and oral optimum temperatures was reported by Nichols and others (1966). Eight percent of the subjects had exactly a one degree Fahrenheit difference. Sixty-seven percent had less than a one degree Fahrenheit difference, and 22 percent had greater than a one degree Fahrenheit difference. The assumption of a one degree Fahrenheit difference between rectal and oral temperatures, as reported in their literature review, was not supported by their study.

Nichols and Glor (1968b) investigated the relationships between optimum oral and rectal temperatures. The difference ranged from zero to 1.2 degrees Fahrenheit with a mean difference of 0.54 degrees Fahrenheit. Only 4 percent had exactly a one degree Fahrenheit difference, and 88 percent had less than a one degree Fahrenheit difference. These results were applicable only to a warm environment. However, further support against the common assumption of plus or minus one degree Fahrenheit difference was presented.

Differences Between Oral and Axillary Temperatures

Loudon (1957) studied axillary and oral temperatures in 75 children, aged three to 15 years. Concurrent oral and axillary recordings were made for three minutes duration. Results showed that oral temperatures were higher than axillary in only 24 subjects. In 29 subjects, the difference was greater than one degree Fahrenheit; in 15 subjects it was less than 0.4 degrees Fahrenheit. In seven subjects the axillary recordings were higher than the oral temperatures. The average difference was 0.8 degrees Fahrenheit with a range from zero to 3.6 degrees Fahrenheit.

George (1965) reported a variation of zero to two degrees Fahrenheit between oral and axillary temperatures. Specifically, an oral temperature may be two degrees Fahrenheit higher than an axilllary temperature, or it may equal it in another individual. Results were inconclusive due to a lack of data and further investigation was indicated.

Nichols and others (1966) found a range of zero to 4.2 degrees Fahrenheit in a comparison of oral and axillary recordings at optimum temperatures. Only 5 percent had an exact one degree Fahrenheit difference. Fifty-seven percent had less than and 35 percent had greater than a one degree Fahrenheit difference. The assumption that axillary temperatures are one degree Fahrenheit lower than oral, as reported by their literature review, was not supported.

In Vietnam, Nichols and Glor (1968b) reported a zero to 1.6 degrees Fahrenheit range with a mean difference of 0.54 degrees Fahrenheit between oral and axillary optimum temperatures. Only 7 percent had exactly a one degree Fahrenheit difference, whereas about 81 percent had less than a one degree Fahrenheit difference. These results indicated that in a majority of subjects, axillary temperatures would be less than one degree Fahrenheit lower than oral temperatures.

Differences Between Skin and Rectal Temperatures

Differences between skin and rectal temperatures in neonates were observed by Hall and Oliver (1971). A visual, noninvasive technique for estimating body temperatures was studied. A clinical trial was conducted, prior to the investigation, which compared mean skin temperatures (from the right upper abdominal quadrant) to rectal temperatures. A mean difference of 0.37 plus or minus 0.02 degrees Celsius between the two sites was found. Further research was indicated because methodology for the clinical trial was not reported.

Fenner and List (1971) placed 17 newborn infants, of varying weights, in servocontrolled incubators and monitored both skin and colon temperatures. In the larger neonates, with a weight greater than 1,500 grams, the colon temperatures were higher than the skin temperatures. In smaller neonates, with a weight less than 1,500 grams, the differences were reversed. The differences in the larger and smaller neonates between skin and colon temperatures were statistically significant ($p < 0.005$).

Coyer (1980) correlated rectal and skin temperatures in 24 neonates, 39-42 weeks gestation, placed in warm (i.e., environmental temperatures of 32 to 33 degrees Celsius) isolettes. Pretest measurements of skin and rectal temperatures with thermistor probes were made upon placement in the isolette. Post-test measurements were made 30 minutes later. An r value was obtained from comparing the measurements (actual value was not reported). Pretest rectal and skin temperatures correlated reaching levels of significance of $p=.01$. During the post-test period, differences between rectal and skin readings were not significant. Coyer concluded that rectal and skin measurements in neonates can be used interchangeably in a rooming-in environment.

Rutter and Hull (1979) observed skin and rectal temperature differences in 30 infants, four hours to 11 days of age. The response of term infants to warm environments, i.e., isolette temperatures greater than 34 degrees Celsius, was studied. A difference between skin and rectal temperatures of 0.5 degrees Celsius was noted when sweating occurred. Results indicated that 0.5 degrees Celsius was a close approximation of the usual differences between the two sites in a warm environment. Further research was needed for the specific differences.

Differences Between Rectal and Axillary Recordings

Torrance (1968) studied the differences between axillary and rectal readings in premature infants. The sample consisted of 120 infants, 34 to 36 weeks gestation, with a minimum weight of 1,500 grams, who had temperatures monitored every half minute for five minutes. Results indicated a mean rectal temperature of 36.55 degrees Celsius and a mean axillary temperature of 36.61 degrees Celsius. The differences between rectal and axillary temperatures of 0.06 degrees Celsius was not significant (p=.05). The results indicated that rectal and axillary temperatures may be used interchangeably in premature infants.

Eoff and others (1974) studied rectal and axillary relationships in neonates. Thirty full-term neonates, with a mean weight of seven pounds, five ounces, and reportedly in good health, had simultaneous axillary and rectal temperatures taken for five minutes, with both a standard glass thermometer and a telethermometer. Results indicated a high correlation between the sites when r=.92 with the glass thermometer and r=.93 with the telethermometer. A 0.49 degree Fahrenheit difference was found between the two sites with the glass thermometer which was significant beyond the p=.01 level. With the telethermometer, a 0.2 degree Fahrenheit average difference was found which was not significant. The evidence reported supported a significant difference between the two sites. However, the results may have led to an unreliable conclusion if the axillary and/or rectal thermometers required more than five minutes to register temperatures.

Kim and others (1977) compared axillary temperatures with rectal recordings in neonates. Four hundred and fifty healthy, term neonates were monitored during their first 12 hours of life. Once admitted to the newborn nursery, with a room temperature of 72.4 degrees Fahrenheit, rectal and axillary temperatures were taken with an electronic thermometer. Axillary recordings were taken during the remaining experimental time. Results of the axillary and rectal recordings were similar. Rectal mean temperature was 36.45 plus or minus 0.89 degrees Celsius, and axillary mean temperature was 36.32 plus or minus 0.62 degrees Celsius. An approximate difference between the two was 0.13 degrees Celsius. Kim and others concluded that the measurement of rectal temperatures corresponds well with axillary temperatures in newborn infants.

Buntain and others (1977) studied axillary and rectal recordings to generate data to permit substituting one method for another. One hundred and five neonates, with specific medical or surgical problems, were divided into two groups. Sixty-nine neonates had rectal temperatures determined with a glass thermometer for three minutes. Axillary temperatures were also obtained using a glass thermometer at three, five, and 10 minute intervals. The other 36 neonates had temperatures determined with an electronic thermometer in both the axillary and rectal sites. Analysis of the data showed that the correlation of axillary and rectal temperatures was higher with a glass thermometer than with an electronic device (p=0.001). The longer the time used in obtaining the axillary reading (r=0.7574 at 10 minutes, p=0.001), the higher the correlation with rectal temperatures. The results indicated that 10 minutes may be necessary for axillary thermometers to register temperatures, and that such a length of time would lead to a high correlation with rectal temperature recordings. However, these results can only be applied to neonates with medical or surgical problems.

Coyer (1980) evaluated whether axillary temperatures correlated with rectal temperatures in neonates. Twenty-four subjects were placed in an isolette and had simultaneous rectal and axillary recordings made and repeated in 30 minutes. Results showed that the first rectal and axillary temperatures correlated reaching levels of significance of p=.01. The two sites correlated during the post-test period reaching levels of significance of p=.01. Coyer recommended that axillary and rectal temperatures can be used interchangeably in a rooming-in environment and in an isolette.

Temperature Differences in Other Body Sites

Rectal, skin, esophageal, and aural (i.e., the external auditory meatus) temperatures were monitored with thermocouplers in 10 term neonates in a metabolic chamber, with an environmental temperature of 33.8 degrees Celsius, by Cross and Stratton (1974). Results showed that aural temperature was 0.15 to 0.2 degrees Celsius higher than esophageal temperature. Rectal temperature was lower than aural or esophageal temperatures. Skin temperatures differed widely from the other temperatures. It was concluded that aural temperatures best reflect core temperatures of neonates. Although evidence was produced to support the usage of aural temperatures, its practicability in general nursing practice has not been established.

Rectal, esophageal, mouth (sublingual), and auditory canal temperature sites were measured by Edwards, Belyavin, and Harrison (1978). Twelve adult subjects had steady-state temperatures taken with thermistors. Results indicated a range of 0.58 degrees Celsius among the four sites. Mean rectal temperatures of 37.36 degrees Celsius were 0.19 degrees Celsius higher than esophageal (significant at $p < .001$). Esophageal temperatures were 0.06 degrees Celsius greater than mean mouth temperatures (not significant), and mouth temperatures were significantly higher than auditory canal temperature by 0.33 degrees Celsius ($p < 0.001$). This information suggested that rectal temperature reflects core body temperature. Although the statistical analysis was reported, the small sample size warranted further investigation. Results from comparisons to the auditory and esophageal sites was not applicable to routine nursing practice.

Influences on Thermoregulation

Evaporative Heat Loss in Neonates

In addition to knowing what factors influence thermometer placement time and differences between various body sites for temperature determination, maternal-child nurses must be aware of sources of heat loss, i.e., by evaporation, in neonates. Such heat loss leads to rapidly changing body temperatures in the early hours of life.

Temperatures in neonates vary widely after birth, according to a study by McClure and Caton (1955).

Twenty-three healthy, term neonates had continuous rectal temperature monitoring for 35 to 45 minutes after birth. Routine newborn care was given during the monitoring in an environmental temperature of 75.6 degrees Fahrenheit, with a 52 percent relative humidity. The investigators concluded that a single temperature recording in the immediate neonatal period "is indicative of the infant's temperature status for only a fleeting moment" (p. 586).

Miller and Oliver (1966) subjected 37 healthy term neonates to three different environmental conditions after delivery. Fourteen infants received routine care (i.e., placed in a basinette with a blanket covering, bathed, and application of an external heat source); 13 received routine care except for a bath, and 10 infants were placed in an incubator (heated to 32.6 to 34.4 degrees Celsius) with routine care delivered through portholes (plus a bath six to 10 hours after birth). Rectal and skin temperatures were monitored with a thermistor probe. Results showed that the group bathed after birth had a mean core temperature drop of 2.3 degrees Celsius, the group without a bath lost 1.8 degrees Celsius of core temperature, and the incubator group had a fall of 1.0 degree Celsius. These differences were significant (level of significance was not reported). Reported results indicated that delaying a bath reduces thermal losses in neonates.

The effects of bathing on a newborn infant were investigated by Whitner and Thompson (1970). The hypotheses of the experiment were that bathing would cause a decrease in newborn body temperature, and would stimulate a more rapid return of normal body temperature. One hundred and sixteen neonates, in an environmental temperature of 72 to 79 degrees Fahrenheit, with a relative humidity of 50 to 55 percent, had their axillary temperatures monitored with a skin probe. Infants were either bathed or not bathed, and had pre- and post-test temperatures recorded. Results confirmed the first hypothesis in that body temperatures were one degree Fahrenheit lower in the bathed group of infants. The second hypothesis was also confirmed in that body temperatures were 0.5 degrees Fahrenheit higher in the bathed infants three to six hours after birth (significant at $p < .05$). This information suggested that bathing an infant after birth will foster thermoregulation in later hours of life.

Dahm and James (1972) evaluated heat loss in newborn infants by monitoring skin and rectal temperatures. Five groups, of 10 infants each, were observed for 30 minutes after birth in a room temperature of 25 degrees Celsius. Results indicated that infants dried and wrapped in a warm blanket (with a mean temperature fall of one degree Celsius) retained body heat similar (at 99 percent confidence limits) to those infants dried and placed under a radiant warmer (mean temperature fall of 0.7 degrees Celsius). Wet infants exposed to room air lost five times more heat compared to infants dried and warmed after birth. The investigators found evidence to support drying and wrapping infants after birth.

Phillips (1974) monitored rectal temperatures in 115 newborn infants to determine heat loss after delivery. All neonates after delivery were dried and wrapped, and either placed in a heated crib or held in mother's arms. Rectal temperatures were taken at five and 15 minutes after birth in both groups. Results revealed that heat loss was within an acceptable range for both groups (0.9 degrees Fahrenheit lost at five minutes; 2.7 degrees Fahrenheit lost at 15 minutes). The difference in the mean temperatures of both groups was not significant at 15 minutes ($p=.05$). The investigator concluded that holding the infant after birth was as adequate as a heated crib in retaining body heat. Since temperatures were monitored using optimum placement time (Nichols and others, 1966), the evidence found supported Phillips's hypothesis.

Smales and Kime (1978) found that radiant heaters and delayed bathing effectively prevented heat loss from newborn infants. Forty term, healthy neonates were studied one and a half hours after birth. Rectal temperatures were monitored with a standard glass thermometer. The group not bathed and placed under a radiant heater were the warmest (i.e., with a rectal temperature of 36.9 plus or minus 0.12 degrees Celsius) and this difference was significant when $p < 0.05$. Results of this study may be inconclusive because duration of thermometer placement time was not reported.

Heat loss through the heads of neonates was investigated by DeSaintonge and others (1979). One hundred and four infants with a weight range of 2,180 to 4,560 grams, had rectal temperatures taken during the first 30 minutes of life with a thermistor probe. After delivery, half of the infants had Gamgee-lined (i.e., vernaid gauze and cotton tissue, medium quality) hats placed on their heads. Rate of fall in rectal temperatures were compared, and the mean fall in the hat group (1.40 plus or minus 0.09 degrees Celsius) was significantly lower ($p < 0.005$) than the fall in the no hat group (1.86 plus or minus 0.12 degrees Celsius). The evidence suggested that heat loss through the head was minimized with hat placement.

Gardner (1979) studied heat loss in newborns placed in heated beds compared to those held by their mothers. Rectal temperatures were taken two minutes and 15 minutes after birth in 19 neonates. Results in both groups, i.e., those held compared to those placed in heated beds, at 15 minutes revealed identical temperatures of 98.1 plus or minus 0.3 degrees Fahrenheit. The temperature drops in both groups 15 minutes after delivery was not significantly different (1.15 plus or minus 0.7 versus 1.1 plus or minus 0.7 degrees Fahrenheit). The investigator concluded that mothers may hold their infants after birth without concern that they may become chilled.

Hill and Shronk (1979) investigated the effect of early infant-parent contact on newborn body temperature.

After birth, 50 infants were assigned to the control group (i.e., a heater transporter). Fifty infants were placed in the experimental group (i.e., parent's arms). Pre- and post-test rectal temperatures were taken with an electronic thermometer. A two tailed t-test showed no significant difference (p=.05) between the temperatures of the two groups. The investigator concluded that infant-parent contact supports neonatal body temperature after birth.

The amount of heat loss in a neonate delivered in tropical conditions was determined by Omene and others (1979). Fifty-three term infants, in six groups, in a delivery room temperature of 27 degrees Celsius, with a relative humidity of 85 to 89 percent, had rectal temperatures recorded for 30 minutes after birth. Results demonstrated the least decrease of core temperature in the groups dried and wrapped in towels after birth (i.e., a 1.3 degrees Celsius and 1.2 degrees Celsius drop respectively). The mean core temperature was significantly higher in those groups compared to the others at 30 minutes. The investigators concluded that drying and wrapping infants in towels was as effective as warming them with a radiant warmer. A drop of two degrees Celsius in core temperature of wet, exposed newborns was also reported. This information should only be applied to areas with the same temperature and relative humidity.

Fardig (1980) compared skin-to-skin contact with mothers to radiant warmers in maintaining newborn temperatures. In this prospective study, skin and rectal temperatures were monitored. Results supported the investigator's hypothesis that body temperatures would be lowest in infants without skin-to-skin contact, higher in delayed contact, and highest in neonates with continuous skin-to-skin contact ($p=0.001$). This information suggested that placement of neonates in mother's arms after birth would promote thermoregulatory maintenance.

Britton (1980) investigated the effect of post-delivery skin-to-skin contact on neonatal temperature stabilization using an experimental design. Thirty-four infants, in two groups, were either placed in a heated crib or held by their mother after delivery. Axillary and rectal temperatures were taken five minutes after birth, and one hour after infants left the delivery room. Results revealed that temperature differences were not significant between groups at the one hour reading. Mean changes in rectal temperature were not significant between those held and those in the crib. Mean changes in axillary temperatures were significant ($p \leq .001$). Axillary temperatures were higher in the group with skin-to-skin contact. The researcher concluded that infants maintained their body temperatures whether placed in a heated crib or held by their mothers.

Metabolism and Physiology in Neonates

Maternal-child nurses must also be aware of physiologic and metabolic factors which influence neonatal thermoregulation. Brück (1961) revealed that neonates exhibited homoiothermic not poikilothermic behavior after birth. Full-term and premature infants, in a climatized chamber with an environmental temperature of 23 to 28 degrees Celsius, had skin blood flow, metabolic reactions, and skin and colon temperatures monitored. Results indicated that the neonate had the ability to increase metabolic rates and vasoconstrict immediately after birth. From the second day of life, heat production in an unclothed neonate was adequate to maintain body temperature at a constant reading of 36.5 degrees Celsius with an air temperature of 23 degrees Celsius. Reported results indicated that infants' thermoregulating abilities were stable after 24 hours of life.

Silverman and others (1964) searched for brown adipose tissue deposits in neonates. Sixteen infants, aged one to 78 days old, with gestational ages of 21 to 40 weeks and weights of 1,300 to 3,720 grams, were placed in an environment of 25.7 degrees Celsius for one to four hours. Skin temperatures at various body sites, and colon temperatures were measured. It was found that the temperature of the nape fell significantly less than other skin temperature sites. Nape temperatures, like colonic temperatures, remained warm during periods of cold stress, without a significant difference between the two sites. Although the presence of a site of brown fat thermogenesis was supported, further investigation was indicated in reference to nape temperatures for specific body weights.

Adamsons, Gandy, and James (1965) investigated the factors influencing metabolic rates in the immediate newborn period. Fifty term neonates, in different environmental temperatures, had their oxygen consumption, rectal and skin temperatures monitored during the study. It was found that oxygen consumption is not dependent upon core or skin temperatures. Smales and Kime (1978) supported these findings. Oxygen consumption was a function of the temperature difference between the environment and skin ($r=0.937$). This information suggested that both skin and environmental temperatures must be monitored in the immediate neonatal period.

Sulyok, Jéquier, and Ryser (1972) researched the effects of relative humidity on neonatal metabolism rates. Thirty-one newborn infants, on their first day of life, were subjected to either 20, 50, or 80 percent relative humidity, at an environmental temperature of 32 degrees Celsius. Heat losses, skin and esophageal temperatures, and metabolic rates were monitored. Results showed that there is a highly significant inverse relationship between the relative humidity and evaporative heat loss ($p < .01$), i.e., the lower the relative humidity, the higher the heat loss. The researchers recommended that a relative humidity of 50 percent may be an optimal condition for neonates.

Tähti and others (1972) studied neonatal reactions to a cold environment during the first five minutes of life. Cinethermography (a method which continuously records heat emission) and skin temperatures were used to monitor 12 healthy term infants. It was found that after birth there was a centripetal progression of heat loss with the highest heat radiation in the skin folds. These results applied only to the first five minutes of life.

Rylander (1972) investigated reactions of infants during exposure to cold. Fifty-eight term infants, zero to six months of age, were exposed to environmental temperatures of 18 to 23 degrees Celsius for 30 minutes. Skin and rectal temperatures were monitored and thermographic recordings were made. Results showed that the temperature decrease during the first hours of life was significant ($p < .001$). From one to 14 days of life, no significant change in rectal temperature occurred during cooling. Skin temperature of the nape was highest during the early days and months of life. At the age of four months, the nape region was cooler than lower parts of the back. The investigators concluded that thermoregulation improved with increased age, and that there was an age-association with heat and emission from the nape of the neck.

Perlstein and others (1974) investigated the neonate's abilities to adapt to a cold environment in the first three days of life. Nineteen term neonates were exposed to different degrees of environmental temperatures and cold stress experiences. Thermistor temperature measurements were made in the rectum, tympanic membrane, and skin regions. Rectal temperatures of each group were not significantly different from tympanic membrane temperatures ($p=.05$). Mean skin temperature falls differed significantly from rectal and tympanic membrane temperatures ($p < .01$). The investigators concluded that neonates had the abilities to maintain core body temperatures in a heat loosing environment.

Skin temperatures at the nape of the neck of infants at a high altitude were examined by Dufour, Little, and Thomas (1976). Three Quecha Indian infants, eight, nine, and 15 months of age, at 4,000 meters above sea level in Peru, had skin temperatures measured at six body sites. Results indicated that the nape of the neck had the highest temperature of all the skin sites. The researchers suggested that brown adipose tissue, associated with non-shivering thermogenesis, was active in regions of high altitude and low oxygen availability. However, due to the limited sample size, further investigation was needed.

Summary

Literature as related to various aspects of this study has been reviewed. Temperature determinations in neonates are influenced by thermometer placement time (according to the site used and the environmental temperature), possibly by gender and race, independent variables, and by the extent of the thermometer insertion. Differences in temperature exist between oral, axillary, and rectal sites. Factors such as evaporative heat loss and the presence of brown fat influence neonatal thermoregulatory processes.

Chapter 3

METHODOLOGY

Introduction

This investigation was a nonexperimental, ex post facto, correlational study. Simultaneous axillary and rectal recordings were obtained from 30 neonates utilizing clinical glass thermometers. The data generated by the study were analyzed statistically to test the hypotheses regarding the differences between the two recordings.

Setting

The setting was the Newborn Nursery of an urban, middle Atlantic teaching hospital and medical center. The nursery has 25 basinettes for private, staff, and Medicaid patients. The nursery temperature is maintained at 72 degrees plus or minus five degrees Fahrenheit with a relative humidity of 50 percent. Infants were lightly clothed in cotton shifts, disposable diapers, and were wrapped in a blanket.

Population

The Newborn Nursery population, from which the investigator selected the study sample, consisted of approximately 750 neonates who were admitted to the nursery during the period of July, 1980 to December, 1980. Neonates in the nursery primarily were delivered vaginally without complications, and were predominately Black.

Sample Selection

The subjects selected for inclusion in this study were 30 neonates admitted to the Newborn Nursery between August, 1980 and January, 1981. Parents of subjects were invited to participate in the study after the neonate's admission records and charts were screened. The neonates whose status was consistent with the study criteria were selected to participate.

The specified criteria for admission to the study were:

1. A maternal history free of transmissible maternal conditions or disease (e.g., Rh incompatibility, and gestational diabetes mellitus);
2. A birth weight of 2,500 grams or greater;
3. An Apgar score at five minutes of seven or greater;
4. A gestational age of 38 to 42 weeks;
5. At least 24 hours post delivery;
6. Reportedly in good health with no known thermoregulating abnormalities; and,
7. The infants had been quietly at rest for one hour preceding testing.

Neonates excluded from the study were:

1. Less than 24 hours of age;
2. Birth weight less than 2,500 grams;
3. Circumcision within one hour prior to testing;
4. Sepsis or hyperbilirubinemia;
5. Gestational age less than 38 weeks;
6. Apgar scores less than seven at five minutes.

Sample

The study sample was comprised of 30, healthy, full-term neonates. Twenty-two male and eight female newborn infants participated. The mean weight of the group was 3,428 grams, with a range of 2,750 to 4,111 grams. Their mean gestational age was 40 weeks, with a range of 38 to 42 weeks. The neonates were between 1.25 and eight days old, with a mean age of 2.9 days. All infants were reported in good health without any overt physiological problems. A complete listing of each subject, gender, weight, gestational age, and Apgar score is shown in Appendix A.

Instruments

Thermometers

Twenty-five Kenwood Brand standard glass rectal thermometers were obtained from the nursery. Each thermometer was inspected visually for defects, intactness, and similarities in design. Once determined that each thermometer appeared functional, a vessel of water, measured by a

Bath thermometer to be 100 degrees Fahrenheit, was obtained. The thermometers were simultaneously placed in the water. After a timed one minute period, the thermometers were removed from the water. The recordings on the thermometers were compared to each other.

Six of the thermometers which registered 100 degrees Fahrenheit were selected to be utilized in the study. Three thermometers were marked A_1 (i.e., Axillary #1), A_2, and A_3. The other three were marked R_1 (i.e., Rectal #1), R_2, and R_3. The thermometers marked A_1 and R_1 were used in the study. The remaining thermometers were made available in the event a thermometer was broken. It was assumed that the glass thermometers used for the temperature measurements remained accurate during their use in the study.

Watch

A Timex Brand watch with a second hand was used to time the one minute intervals for the 12 minutes of recordings. The second hand on the watch was assumed to be accurate, and no calibrations were performed.

Investigator Reliability

Investigator reliability for reading the standard mercury thermometers was determined. The registration of 100 degrees Fahrenheit, in the six thermometers selected by the researcher for usage in the study, was confirmed by a research assistant. A 100 percent agreement on the thermometer readings was made. Periodically, throughout the data collection process, a reliability check of the thermometer readings by the researcher, with an assistant, resulted in a 95 percent agreement.

Data Collection

Consent from the Director of Nursing of the hospital was obtained. Each parent of an eligible patient, selected by the criteria described previously, was approached by the investigator and invited to participate in the study. The purpose and procedures of the study were presented to the parent, and the consent form was read. Emphasis was placed on subject confidentiality and the option to withdraw the neonate from the study at anytime. If the parent agreed to have the neonate participate, then written consent was obtained (Appendix D, Parent's Consent Form).

The temperatures were obtained on each infant between 2:00 p.m. and 5:00 p.m. in the nursery after the consent was signed. The infants at that time had been resting quietly for at least an hour. Each neonate was positioned supine in an open basinette with their cotton shirt and disposable diapers opened. The watch, axillary thermometer, and lubricated rectal thermometers were readied.

Twelve-minute simultaneous measurements of axillary and rectal temperatures were taken on the subjects. Each subject had thermometers A_1 and R_1, each reading 95 degrees Fahrenheit, inserted simultaneously three centimeters into the rectum and under the left axilla. The temperatures were read and recorded by the researcher at one minute intervals from the easily visible mercury columns. The procedure was continued for a total of 12 readings.

After the temperature measurements were made, the neonates were redressed and repositioned in the basinette, and the thermometers were cleaned.

Summary

Thirty full-term neonates were studied after 24 hours of life. Simultaneous measurements of axillary and rectal temperatures were made in 22 male and eight female subjects. A total of 12 recordings at one minute intervals was obtained from each site using clinical glass thermometers.

Chapter 4

DATA ANALYSIS

Introduction

An ex post facto research study of 30 male and female newborn subjects was conducted to test hypotheses concerning the differences between axillary and rectal temperature recordings and the relationship between the two recordings. The two hypotheses tested were:

1. Significant differences exist between simultaneous axillary and rectal temperature recordings in neonates.

2. There is a direct and positive correlation between axillary and rectal temperature recordings at specified time intervals in neonates.

In order to test the above hypotheses, the length of time required for clinical glass thermometers to register the temperature in the rectal and axillary sites was first determined.

Rectal Thermometer Placement Time

Twelve one-minute simultaneous thermometer readings of rectal and axillary temperatures were made in 30 full-term neonates. The maximum temperature, or "the highest reading of a thermometer during a 12 minute period" (Nichols and others, 1966, p. 307) was determined for each neonate using the rectal site. The optimum temperature, or "the maximum temperature minus 0.2 degree Fahrenheit" (Nichols and others, 1966, p. 307) was determined for each subject (Appendix B).

Maximum and optimum rectal thermometer placement time was calculated by computing the cumulative percent of the subject's thermometers reaching maximum and optimum rectal temperatures at various time intervals. The cumulative percents are indicated in Tables 1 and 2, and in Figure 1.

Table 1

Cumulative Percent of Subject's Thermometers Reaching Maximum Rectal Temperatures at Various Time Intervals

	Minutes											
	1	2	3	4	5	6	7	8	9	10	11	12
N-Frequency of Subjects	2	5	11	6	1	1	0	1	1	0	1	1
Percent	7	17	37	20	3.3	3.3	0	3.3	3.3	0	3.3	3.3
Cumulative Percent	7	24	61	81	84	88	88	91	94	94	98	100

Table 2

Cumulative Percent of Subject's Thermometers Reaching Optimum Rectal Temperatures at Various Time Intervals

	Minutes											
	1	2	3	4	5	6	7	8	9	10	11	12
N-Frequency of Subjects	8	12	5	4	1							
Percent	27	40	17	13.3	3.3							
Cumulative Percent	27	67	84	97	100							

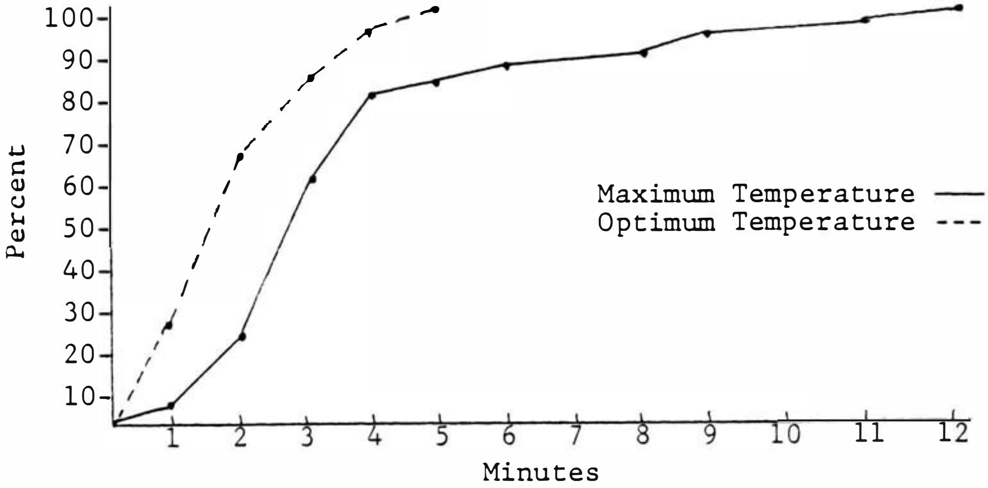

Figure 1

Cumulative Percent of Subject's Thermometers Reaching Maximum and Optimum Rectal Temperatures at Various Time Intervals

In this sample, one to 12 minutes was required for rectal thermometers to register the subject's maximum temperature. Approximately 24 percent of the thermometers registered the subject's maximum temperature in two minutes, 81 percent in four minutes, and over 90 percent in eight minutes. The maximum placement time for rectal thermometers to register the subject's temperature was eight minutes.

One to five minutes was the duration required for rectal thermometers to register the subject's optimum temperature. Approximately 27 percent of the thermometers registered the subject's optimum temperature in one minute, 67 percent at two minutes, and over 90 percent in four minutes. The optimum placement time for rectal thermometers to register the subject's temperature was four minutes.

Axillary Thermometer Placement Time

Maximum and optimum axillary thermometer placement time was determined by listing the cumulative percent of the subject's thermometers reaching maximum and optimum axillary temperatures at various time intervals. The cumulative percents are indicated in Tables 3 and 4, and Figure 2.

Table 3

Cumulative Percent of Subject's Thermometers Reaching
Maximum Axillary Temperatures at Various
Time Intervals

	Minutes											
	1	2	3	4	5	6	7	8	9	10	11	12
N-Frequency of Subjects	0	2	1	3	1	5	0	4	7	3	0	4
Percent	0	7	3.3	10	3.3	17	0	13.3	23.3	10	0	13.3
Cumulative Percent	0	7	10	20	24	41	41	54	77	87	87	100

Table 4

Cumulative Percent of Subject's Thermometers Reaching
Optimum Axillary Temperatures at Various
Time Intervals

	Minutes											
	1	2	3	4	5	6	7	8	9	10	11	12
N-Frequency of Subjects	1	1	8	3	3	8	2	3	1			
Percent	3.3	3.3	27	10	10	27	7	10	3.3			
Cumulative Percent	3.3	7	34	44	54	81	88	98	100			

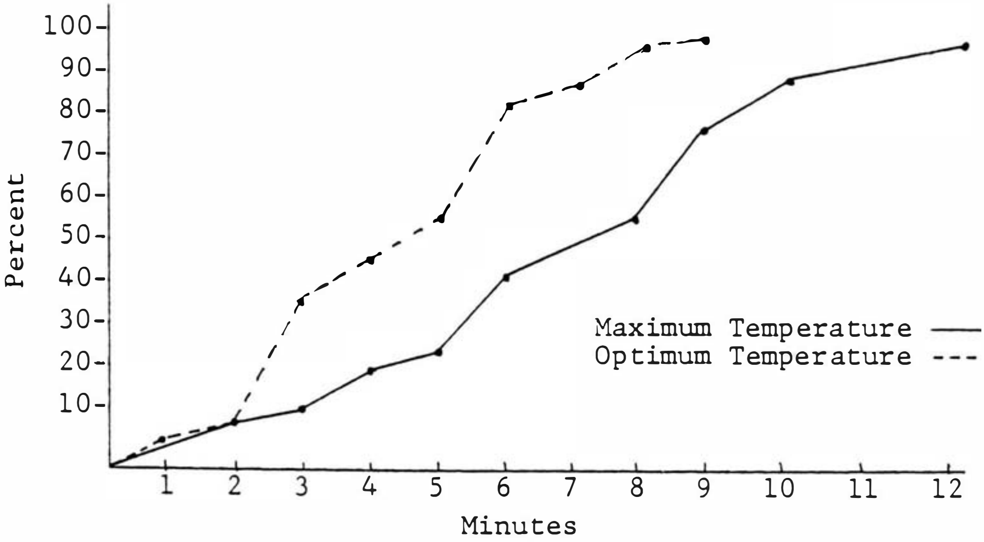

Figure 2

Cumulative Percent of Subject's Thermometers Reaching
Maximum and Optimum Axillary Temperatures
at Various Time Intervals

In this sample, maximum axillary thermometer readings required two to 12 minutes to register the subject's temperature. Approximately 20 percent of the thermometers registered the subject's maximum temperature recording in four minutes, 54 percent in eight minutes, and over 90 percent in 12 minutes. The maximum placement time for axillary thermometers to register the subject's temperature was 12 minutes.

One to nine minutes was the duration required for axillary thermometers to register the subject's optimum temperatures. Approximately 34 percent of the thermometers registered the subject's optimum temperature in three minutes, 81 percent in six minutes, and over 90 percent in eight minutes. The optimum placement time for axillary thermometers to register the subject's temperature was eight minutes.

Thermometer Readings

A frequency distribution of the temperature readings obtained from each of the 30 neonates is presented in Table 5.

Table 5

Frequency Distribution of Temperature Readings for 30 Neonates

Degrees Fahrenheit	Maximum Temperatures		Optimum Temperatures	
	Rectal	Axillary	Rectal	Axillary
95.0 to 95.9	0	0	0	0
96.0 to 96.9	0	0	0	0
97.0 to 97.9	1	1	1	2
98.0 to 98.9	8	14	16	17
99.0 to 99.9	20	14	12	10
100.0 to 100.9	1	1	1	1
101.0 to 101.9	0	0	0	0

In this sample, a majority of the rectal and axillary thermometer registrations clustered around 98.0 to 99.9 degrees Fahrenheit.

The range, mean, and standard deviation for the maximum and optimum rectal axillary thermometer registrations are indicated in Table 6.

Table 6

Range, Mean, and Standard Deviation for Maximum and Optimum Rectal and Axillary Thermometer Recordings[1]

Method	Range		Mean		Standard Deviation	
	Maximum Temperature	Optimum Temperature	Maximum Temperature	Optimum Temperature	Maximum Temperature	Optimum Temperature
Rectal	97.6 to 100.4	97.4 to 100.4	99.05	98.88	.49	.51
Axillary	97.8 to 100.4	97.6 to 100.2	98.87	98.70	.47	.48

[1] All temperatures are recorded in degrees Fahrenheit.

Difference Between Rectal and Axillary Temperature Recordings

Rectal and axillary temperature readings for each neonate, at maximum and optimum temperatures, were compared. The difference between the two sites in each neonate was determined (Appendix C). This determination was made by subtracting the axillary temperature from the rectal temperature recording in each neonate.

The frequency distribution of the differences between rectal and axillary temperature recordings in the subjects is indicated in Figure 3 and Table 7. The mean differences between the recordings are also included in Table 7.

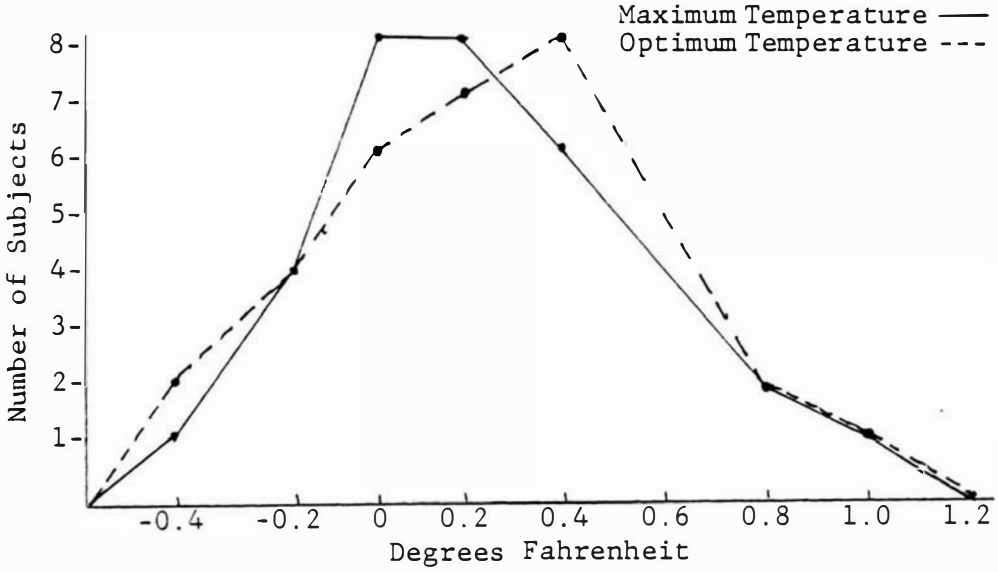

Figure 3

Differences Between Rectal and Axillary Temperature Readings at Maximum and Optimum Placement Time

Table 7

Frequency Distribution of Differences Between Rectal and Axillary Temperature Readings in 30 Neonates,[1] Mean Difference

Differences (Degrees Fahrenheit)	Frequency N of Subjects	
	Maximum Temperature	Optimum Temperature
-0.4	1	2
-0.2	4	4
0	8	6
0.2	8	7
0.4	6	8
0.6	0	0
0.8	2	2
1.0	1	1
Mean Difference (Degrees Fahrenheit)	0.18	0.19

[1] Difference = Rectal temperature minus axillary temperature.

In this sample, the distribution of the differences between rectal and axillary temperature readings clusters around 0 to 0.4 degrees Fahrenheit. The mean differences between the maximum and optimum temperatures are closely related.

To test the hypothesis that significant differences exist between simultaneous axillary and rectal temperature recordings in neonates, a method of analyzing paired data was used. This method, a Paired T-test, is implemented when the researcher obtains "two measures from the same subjects" (Polit and Hungler, 1978, p. 550). In this study, two sets of data were collected from the same subject, i.e., rectal and axillary temperature recordings.

Data analysis, utilizing the Paired T-test method, indicated that the mean maximum rectal temperature recordings significantly exceeded mean maximum axillary temperature recordings ($t=3.11$, d.f.=29, $p < .01$).

The mean optimum rectal temperature recordings significantly exceeded mean optimum axillary temperature recordings when data were further analyzed utilizing the Paired T-test method ($t=3.05$, d.f.=29, $p < .01$).

The null hypothesis was rejected, and the research hypothesis was accepted (i.e., significant differences exist between rectal and axillary temperature recordings).

Correlation Coefficients for Rectal and Axillary Temperature Recordings

To test the hypothesis that there is a direct and positive correlation between axillary and rectal temperature recordings at specified intervals in neonates, the Pearson product moment correlation coefficient ('r' statistic) was used. This statistic provided a correlation index for interval data to determine the direction and degree of the linear relationship between the two temperature recordings. The results of the Pearson r are illustrated on scatter plots for maximum and optimum temperature recordings in Figures 4 and 5.

The characteristics of the scattergrams revealed a "moderate positive correlation" (Polit and Hungler, 1978, p. 530) between both maximum and optimum temperature recordings.

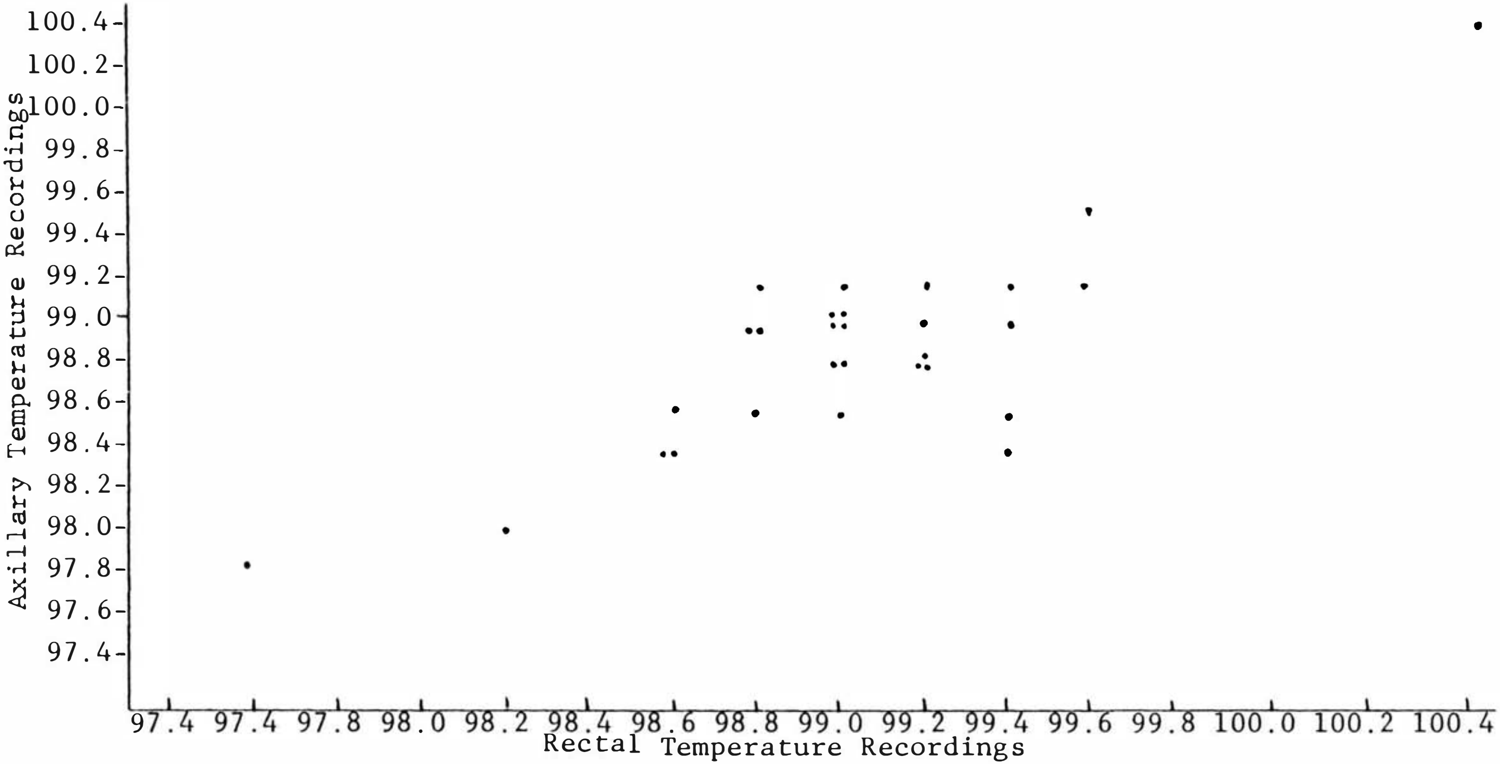

Figure 4

Scattergram for Rectal and Axillary Maximum
Temperature Recordings
in Degrees Fahrenheit

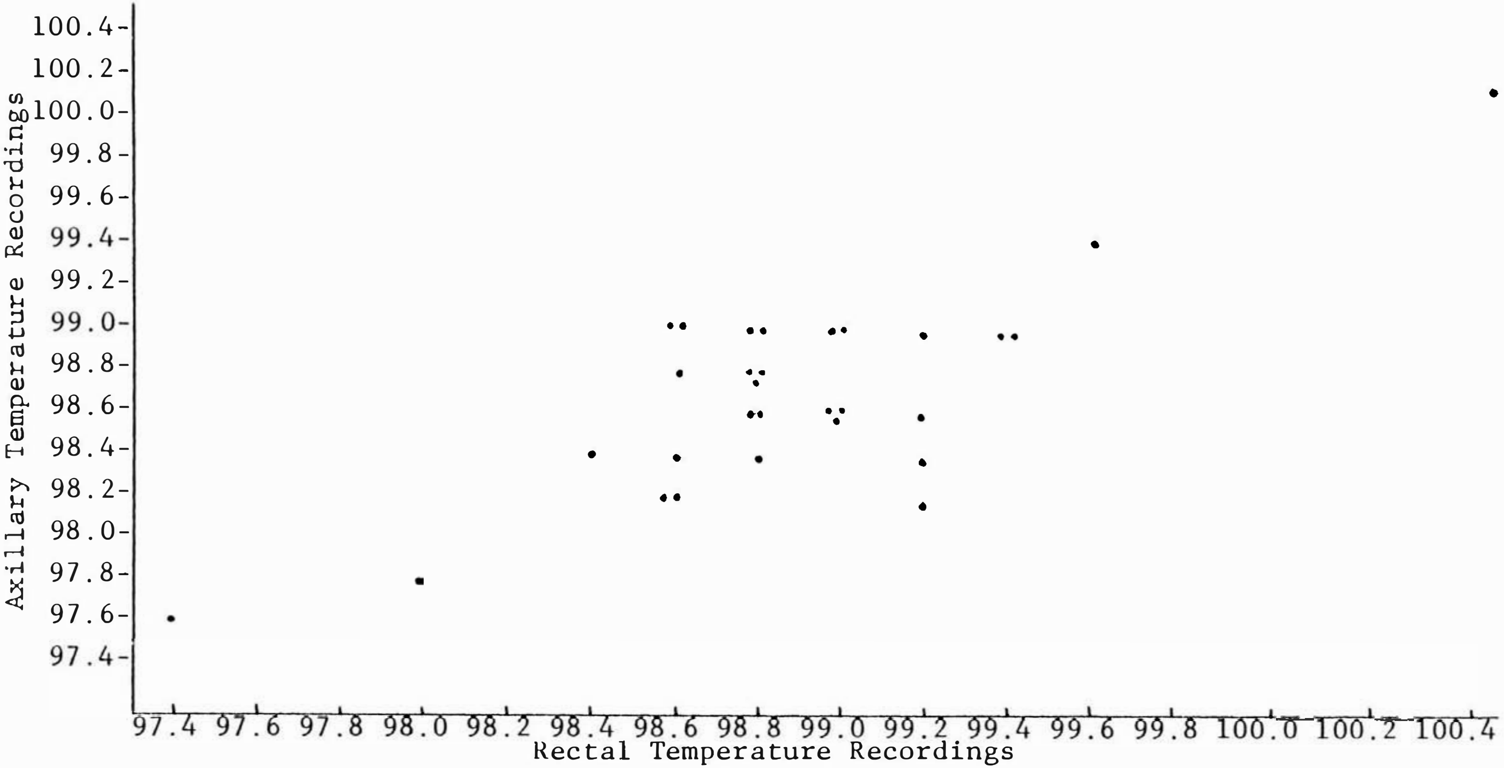

Figure 5

Scattergram for Rectal and Axillary Optimum
Temperature Recordings
in Degrees Fahrenheit

Table 8 contains 'r' values for maximum and optimum temperature recordings.

Table 8

Total Correlation Values for Maximum and Optimum Temperature Recordings
($p < .01$, d.f.=28)

Recordings	Pearson 'r' Value
Maximum Rectal and Axillary Temperature	0.78
Optimum Rectal and Axillary Temperature	0.79

In this sample, there was a significant correlation ($p < .01$) between maximum rectal and axillary temperature recordings and between optimum rectal and axillary temperature recordings. The data supported the research hypothesis.

Discussion

The following factors may have influenced data collection and the results of data analysis.

1. Results of this study indicated that there is a significant difference between simultaneous rectal and axillary temperature recordings in neonates ($p < .01$). As discussed in Chapter 2, other studies found that race, gender, exact location and thermometer placement and

environmental conditions may influence temperature recordings in neonates. These factors may have enhanced the differences between temperature recordings in this study to a significant level ($p < .01$). However, data analysis supported the research hypothesis.

2. One of this study's purposes was to test Roy's premise that rectal temperature recordings are one degree Fahrenheit higher than oral, and that axillary temperature recordings are one-half degree Fahrenheit lower than oral temperature recordings (Poush, 1976). A one and a half degree Fahrenheit difference between rectal and axillary temperature recordings would be assumed from such a premise. The data from this study revealed a mean maximum temperature difference of .18 degrees Fahrenheit and a mean optimum temperature difference of .19 degrees Fahrenheit between rectal and axillary temperature recordings. These results do not support Roy's premise (Poush, 1976). This lack of support may have been due to the subject's body size and age. However, the difference results of this study are only applicable to this study's sample.

3. Results of this study demonstrated that there was a significant correlation ($p < .01$) between maximum and optimum rectal and axillary temperature recordings. These results may have been influenced by thermometer placement time, i.e., the longer the time, the higher the correlation as discussed in Chapter 2 (Buntain and others, 1977).

4. Results of this study indicated that the optimum placement time for rectal and axillary thermometers was four minutes and eight minutes, respectively. The maximum placement time for rectal and axillary thermometers was eight minutes and 12 minutes, respectively. These results may have been influenced by the exact placement of the thermometer, the environmental surroundings, or by the thermometers implemented in the study.

Chapter 5 will discuss the investigator's summary, conclusions of the study, implications for nursing practice, and recommendations for future nursing research.

Chapter 5

SUMMARY, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Summary

The purposes of this ex post facto research study were to answer the following questions:

1. What is the length of time required for glass thermometers to register the temperature in neonates at the rectal and axillary sites?

2. Do significant differences exist between simultaneous axillary and rectal temperature recordings in neonates?

3. What is the relationship between axillary and rectal temperature recordings at specified time intervals in neonates?

A sample of 30, full-term neonates was obtained from the Newborn Nursery of a large teaching hospital in the Middle Atlantic region. All participants were over 24 hours of age and weighed greater than 2,500 grams. Each subject had simultaneous axillary and rectal temperature recordings made at one minute intervals over a 12 minute period.

Data analysis was performed which determined thermometer placement time, mean, range and standard deviation of temperature recordings, level of significance for the differences between axillary and rectal sites, and the correlation between rectal and axillary temperature recordings.

Conclusions

On the basis of the data analysis, the data from this study supported the two stated hypotheses:

1. Significant differences exist between simultaneous axillary and rectal temperature recordings in neonates ($p < .01$).

2. There is a direct and positive correlation between axillary and rectal temperature recordings at specified time intervals in neonates ($p < .01$).

The following conclusions were also drawn from these data:

1. The maximum placement time for rectal thermometers to register the neonate's temperatures was eight minutes. The optimum placement time for rectal thermometers was four minutes.

2. The maximum placement time for axillary thermometers to register the neonate's temperatures was 12 minutes. The optimum placement time for axillary thermometers was eight minutes.

3. The mean rectal maximum temperature in neonates was 99.05 plus or minus .49 degrees Fahrenheit. The mean rectal optimum temperature was 98.88 plus or minus .51 degrees Fahrenheit.

4. The mean axillary maximum and optimum temperatures in neonates were 98.87 plus or minus .47 degrees Fahrenheit and 98.7 plus or minus .48 degrees Fahrenheit, respectively.

5. The mean difference between maximum rectal and axillary recordings was 0.18 degrees Fahrenheit. The mean difference between optimum rectal and axillary recordings was 0.19 degrees Fahrenheit.

Implications for Nursing

As a result of this study, the following implications for nursing practice are implied:

1. A longer thermometer placement time for determining rectal and axillary temperature recordings in neonates may be indicated.

2. Although significant differences between simultaneous axillary and rectal temperature recordings exist in neonates ($p < .01$), the small difference (i.e., 0.18 degrees Fahrenheit for maximum temperatures and 0.19 degrees Fahrenheit for optimum temperatures) between the two sites may not greatly influence nursing care of neonates.

3. In a constant environmental temperature, axillary and rectal temperature recordings may be used interchangeably in neonates (based on #2, above).

Recommendations for Further Study

It is recommended that this study be replicated:

1. Using a larger sample size of neonates to retest this study's hypotheses.

2. Comparing axillary and rectal temperature recordings of a clinical glass thermometer with an electronic thermometer.

3. Specifically determine if gender, age, race, or weight influence thermometer placement time in neonates.

4. Comparing neonatal temperatures in varying environmental temperatures.

REFERENCES

REFERENCES

Adamsons, Karlis, Jr.
1966 "The Role of Thermal Factors in Fetal and Neonatal Life." Pediatric Clinics of North America 13 (August):599-619.

Adamsons, K., Jr., G. M. Gandy, and L. S. James
1965 "The Influence of Thermal Factors Upon Oxygen Consumption of the Newborn Human Infant." Journal of Pediatrics 66 (March):495-507.

Adamsons, Karlis, Jr., and Molly E. Towell
1965 "Thermal Homeostasis in the Fetus and Newborn." Anesthesiology 26 (July-August):531-48.

Bennett, Edward J., Kanchan P. Patel, and Ernest M. Grundy
1977 "Neonatal Temperature and Surgery." Anesthesiology 46 (April):303-304.

Blainey, Carol G.
1974 "Site Selection in Taking Body Temperatures." American Journal of Nursing 74:1859-61.

Britton, Geraldine R.
1980 "Early Mother-Infant Contact and Infant Temperature Stabilization." J.O.G.N. Nursing 9 (March-April): 4-6.

Brück, Kurt
1961 "Temperature Regulation in the Newborn Infant." Biologia Neonatorum 3:65-119.

Buntain, William L., Mary Pregler, Peter C. O'Brien, and Hugh B. Lynn
1977 "Axillary Versus Rectal Temperature: A Comparative Study." Journal of Louisiana State Medical Society 129 (January):5-8.

Capobianco, Julia Adams
1980 "How to Safeguard the Infant Against Life-Threatening Heat Loss." Nursing '80 10 (May):64-67.

Coyer, Sharon
1980 "Correlation Between Rectal, Axillary, and Skin Temperatures in the Newborn." Xenia, Ohio, unpublished manuscript.

Cranston, W. I., J. Gerbrandy, and E. S. Snell
1954 "Oral, Rectal and Oesophageal Temperatures and Some Factors Affecting Them in Man." Journal of Physiology 126:347-58.

Cross, K. W. and D. Stratton
1974 "Aural Temperature of the Newborn." The Lancet 2 (November):1179-80.

Dahm, Lida Swafford and L. Stanley James
1972 "Newborn Temperature and Calculated Heat Loss in the Delivery Room." Pediatrics 49:504-12.

DeSaintonge, D. M. Chaput, K. W. Cross, M. K. S. Hathorn, Sheila R. Lewis, and J. K. Strothers
1979 "Hats for the Newborn Infant." British Medical Journal 2:570-71.

Dufour, Darna L., Michall A. Little, and R. Brooke Thomas
1976 "Skin Temperatures at the Nape in Infants at High Altitude." American Journal of Physical Anthropology 44 (January):91-94.

DuGas, Beverly W.
1977 Introduction to Patient Care: A Comprehensive Approach to Nursing. Philadelphia: W. B. Saunders Company.

Edwards, R. J., A. J. Belyavin, and M. H. Harrison
1978 "Core Temperature Measurement in Man." Aviation, Space and Environmental Medicine 49 (November): 1289-94.

Eoff, Mary Jo Fike, Robert S. Meier, and Carol Miller
1974 "Temperature Measurements in Infants." Nursing Research 23 (November-December):457-60.

Erickson, Roberta
1976 "Thermometer Placement for Oral Temperature Measurement in Febrile Adults." International Journal of Nursing Studies 13:199-208.

Erickson, Roberta
1980 "Oral Temperature Differences in Relation to Thermometer and Technique." Nursing Research 292 (May-June):157-64.

Erickson, Roberta and Frances Storlie
1973 "Taking Temperatures: Oral or Rectal, and When?" Nursing '73 3 (April):51-53.

Färdig, Judith A.
1980 "A Comparison of Skin-to-Skin Contact and Radiant Heaters in Promoting Neonatal Thermoregulation." Journal of Nurse-Midwifery 25 (January-February): 19-28.

Fenner, A. and M. List
1971 "Observations of Body Temperature Regulation in Young Premature and Full-Term Newborns While Being Connected to a Servo-Control Temperature Unit." Biological Neonate 18:300-10.

Fonkalsrud, Eric W. and H. William Clatworthy, Jr.
1965 "Accidental Perforation of the Colon and Rectum in Newborn Infants." New England Journal of Medicine 272 (May):1097-1100.

Forster, Brenda, Diane C. Adler, and Mardell Davis
1970 "Duration of Effects of Drinking Iced Water on Oral Temperature." Nursing Research 19 (March-April): 169-70.

Frank, J. D. and S. Brown
1978 "Thermometers and Rectal Perforation in the Neonate." Archives of Disease in Childhood 53 (October):824-25.

Gardner, Sherry
1979 "The Mother as Incubator-After Delivery." J.O.G.N. Nursing 8 (May-June):174-76.

George, Joyce Holmes
1965 "Electronic Monitoring of Vital Signs." American Journal of Nursing 65 (February):68-71.

Graas, Susan
1974 "Thermometer Sites and Oxygen." American Journal of Nursing 74 (October):1862-63.

Guyton, Arthur C.
1981 Textbook of Medical Physiology. Philadelphia: W. B. Saunders Company.

Hall, Robert T. and Thomas K. Oliver, Jr.
1971 "Visual Estimate of Body Temperature in Neonates." J.A.M.A. 144 (December):1562-65.

Heim, Tibor
1971 "Thermogenesis in the Newborn Infant." Clinical Obstetrics and Gynecology, L. Stern, editor. September, pp. 790-817.

Hey, E. N. and G. Katz
1970 "The Optimum Thermal Environment for Naked Babies." Archives of Disease in Childhood 45:328-34.

Hill, Susan, T. and Lucille K. Shronk
1979 "The Effect of Early Parent-Infant Contact on Newborn Body Temperature." J.O.G.N. Nursing 8 (September-October):287-90.

Horvath, Steven M., H. Menduke, and George Morris Piersol
1950 "Oral and Rectal Temperatures of Man." J.A.M.A. 144 (December):1562-65.

Hull, David
1966 "The Structure and Function of Brown Adipose Tissue." British Medical Bulletin 22:92-96.

Kanto, William P., Jr., and Lynnette J. Calvert
1977 "Thermoregulation of the Newborn." American Family Physician 16 (November):157-63.

Kim, C. B., Benjamin A. Ranck, Eileen B. Dean, and Patricia Walker
1977 "The Temperature in Normal Term Newborns in the First Twelve Hours." Journal of the Indiana State Medical Association 70 (November):863-64.

Loudon, I. S. L.
1957 "On Taking the Temperature in the Mouth and Axilla." The Lancet 57 (August):233-35.

Lutz, Linda and Paul H. Perlstein
1971 "Temperature Control in Newborn Babies." Nursing Clinics of North America 6:15-23.

Marlow, Dorothy
1977 Textbook of Pediatric Nursing. Philadelphia: W. B. Saunders Company.

McClure, James and William L. Caton
1955 "Newborn Temperature--1. Temperature of Term Normal Infants." Journal of Pediatrics 47 (November):583-87.

McCormick, Rose-Marie Duda and Tamar Gilson-Parkevich
1979 Patient and Family Education--Tools, Techniques, and Theory. New York: John Wiley and Sons, Inc.

Merenstein, Gerald B.
1970 "Rectal Perforation by Thermometers." The Lancet 1 (May):1007.

Miller, D. L. and T. K. Oliver, Jr.
1966 "Body Temperature in the Immediate Neonatal Period: The Effect of Reducing Thermal Losses." American Journal of Obstetrics and Gynecology 94 (April): 964-69.

Motil, Kathleen J. and Michael G. Blackburn
1973 "Temperature Regulation in the Neonate--A Survey of the Pathophysiology of Thermal Dynamics and of the Principles of Environmental Control." Clinical Pediatrics 12 (November):634-39.

Nalepka, Claire D.
1976 "Understanding Thermoregulation in Newborns." J.O.G.N. Nursing 5:17-19.

Nelson, Waldo E.
1979 Textbook of Pediatrics. Philadelphia: W. B. Saunders Company.

Nichols, Glennadee A.
1968 "Measurements of Oral Temperature in Children." Journal of Pediatrics 72 (February):253-55.

Nichols, Glennadee A.
1972 "Taking Adult Temperatures--Rectal Measurements." American Journal of Nursing 72 (June):1092-93.

Nichols, Glennadee A., Jane J. Fielding, Rosemary K. McKevitt, and Iris Posner
1969 "Taking Oral Temperatures of Febrile Patients." Nursing Research 19 (September-October):448-50.

Nichols, Glennadee A. and Beverly A. K. Glor
1968 "A Replication of Rectal Thermometer Studies." Nursing Research 17 (July-August):360-61.

Nichols, Glennadee A. and Beverly A. K. Glor
1968b "Temperature Taking Times in Vietnam." Military Medicine 133 (February):154-58.

Nichols, Glennadee A. and Deloros H. Kucha
1972 "Oral Measurements." American Journal of Nursing 72 (June):1091-93.

Nichols, Glennadee A., Deloros H. Kucha, and Rosemarie P. Mahoney
1972 "Rectal Thermometer Placement Times for Febrile Adults." Nursing Research 21 (January-February): 76-77.

Nichols, Glennadee A., Ruth L. Kulvi, Hazel R. Life, and Nancy M. Christ
1972 "Measuring Oral and Rectal Temperatures of Febrile Children." Nursing Research 21 (May-June):261-64.

Nichols, Glennadee A., Margaret M. Ruskin, Beverly A. K. Glor, and Willie H. Kelly
1966 "Oral, Axillary, and Rectal Temperature Determinations and Relationships." Nursing Research 15:307-10.

Nichols, Glennadee A. and Phyllis J. Verhonick
1967 "Time and Temperature." American Journal of Nursing 67 (November):2304-2306.

Oliver, T. K., Jr.
1975 "Temperature Regulation and Heat Production in the Newborn." Pediatric Clinics of North America 12 (August):765-79.

Omene, J. A., F. M. E. Diejomaoh, M. Faal, M. A. Diakparomre, and M. Obiaya
1979 "Heat Loss in Nigerian Newborn Infants in the Delivery Room." International Journal of Gynaecology and Obstetrics 16:300-302.

Perlstein, Paul, Carol Hersh, Charles J. Gluech, and James M. Sutherland
1974 "Adaptation to Cold in the First Three Days of Life." Pediatrics 54 (October):411-15.

Phillips, Celeste R. Nagel
1974 "Neonatal Heat Loss in Heated Cribs Versus Mothers' Arms." J.O.G.N. Nursing 3 (November-December):11-15.

Polit, Denise F. and Bernadette P. Hungler
1978 Nursing Research: Principles and Methods. Philadelphia: J. B. Lippincott Company.

Porth, Carol M. and Leone E. Kaylor
1978 "Temperature Regulation in the Newborn." American Journal of Nursing 78:1691-93.

Poush, Mary
1976 Introduction to Nursing: An Adaptation Model, Sister Callista Roy, editor. Englewood Cliffs, New Jersey: Prentice-Hall, Inc.

Reynolds, Janet
1978 "How to Take a Temperature." Pediatric Nursing 4 (November-December):67.

Riehl, Joan P. and Sister Callista Roy
1974 Conceptual Models for Nursing Practice. New York: Prentice-Hall, Inc.

Roy, Sister Callista
1970 "Adaptation: A Conceptual Framework for Nursing." Nursing Outlook 18:42-45.

Roy, Sister Callista
1971 "Adaptation: A Basis for Nursing Practice." Nursing Outlook 19 (April):254-57.

Rutter, N. and D. Hull
1979 "Response of Term Babies to a Warm Environment." Archives of Disease in Childhood 54:178-83.

Rylander, Eva
1972 "Age Dependent Reactions of Rectal and Skin Temperatures of Infants During Exposure to Cold." Acta Paediatrica Scandinavica 61:597-605.

Scopes, J. W.
1970 "Control of Temperature in Newborn Babies." The Scientific Basis of Medicine Annual Reviews, pp. 31-50.

Scopes, J. W.
1975 "Thermal Control in Premature Infants." Annual Reviews of Medicine 23:129-48.

Sellars, Jacqueline H. and Ann E. Yoder
1961 "A Comparative Study of Temperature Readings." Nursing Research 10 (Winter):43-45.

Silverman, William A., Ansis Zamelis, John C. Sinclair, and Frederic J. Agate, Jr.
1964 "Warm Nape of the Newborn." Pediatrics 33 (June): 984-87.

Sinclair, John C.
1972 "Thermal Control in Premature Infants." Annual Reviews of Medicine 23:129-48.

Smales, O. R. C. and R. Kime
1978 "Thermoregulation in Babies Immediately After Birth." Archives of Disease in Childhood 53:58-61.

Smith, Clement A. and Nicholas M. Nelson
1976 The Physiology of the Newborn Infant. Springfield, Illinois: Charles C. Thomas, Publisher.

Spitz, Phyllis and Hannelore Sweetwood
1978 "Kids in Crisis--Part 1: Bedside Assessment--Special Considerations." Nursing '78 8 (March):70-79.

Stern, L.
1978 "Physiology of the Newborn Infant II: Thermal Regulation." Progress in Pediatric Surgery 12:23-40.

Strydom, N. B., J. F. Morrison, J. Booyens, and J. Peter
1956 "Comparison of Oral and Rectal Temperatures During Work in Heat." Journal of Applied Physiology 8 (January):406-408.

Sulyok, E., E. Jéquier, and L. S. Prod'hom
1973 "Thermal Balance of the Newborn Infant in a Heat-Gaining Environment." Pediatric Research 7:88-90.

Sulyok, E., E. Jéquier, and G. Ryer
1972 "Effect of Relative Humidity on Thermal Balance of the Newborn Infant." Biological Neonate 21:210-18.

Tähti, E., J. Lind, K. Osterlund, and Eva Rylander
1972 "Changes in Skin Temperature of the Neonate at Birth--A Cine-thermographic Study." Acta Paediatrica Scandinavica 61:159-64.

"Temperatures and Their Accuracy." Nursing Times 67
1971 (September):1139.

Torrance, Jane T.
1968 "Temperature Readings of Premature Infants." Nursing Research 17 (July-August):313-20.

VanLeeuwen, G. and L. Glenn
1968 "Screening for Hidden Congenital Anomalies." Pediatrics 41 (January):147-49.

Verhonick, Phyllis J. and Glennadee A. Nichols
1968 "Temperature Measurement in Nursing Practice and Research." The Canadian Nurse 64 (June):41-43.

Verhonick, Phyllis J. and Harriet H. Werley
1963 "Experimentation in Nursing Practice in the Army." Nursing Outlook 11 (March):204-206.

Waechter, Eugenia H. and Florence G. Blake
1976 Nursing Care of Children. Philadelphia: J. B. Lippincott Company.

Washington, Sherrill
1978 "Temperature Control of the Neonate." Nursing Clinics of North America 13:28.

Whitner, Willamay and Margaret C. Thompson
1970 "The Influence of Bathing on the Newborn Infant's Body Temperature." Nursing Research 19 (January-February):30-36.

Wilkinson, Vivienne, Terence McGinn, and Ann Tregilgas
1971 "Temperatures and their Accuracy." Nursing Times 67 (September):1139.

Woodman, Ellen A., Susan McConnell Parry, and Lillian Simms
1967 "Sources of Unreliability in Oral Temperatures." Nursing Research 16 (Summer):276-79.

Zuidema, George D.
1977 The Johns Hopkins Atlas of Human Functional Anatomy. Baltimore: The Johns Hopkins University Press.

APPENDIX A

SUMMARY OF SUBJECTS

SUMMARY OF SUBJECTS[1]

Subject	Gender	Age (days)	Weight (grams)	Gestational Age (weeks)	Apgar Score
1	M	1.5	3657	40	9-9-9
2	M	3	3699.5	40	8-9-9
3	M	2	3090	40	8-9-9
4	M	1.5	3544	40	9-9-9
5	M	2	3572	40	8-9-9
6	F	5	3657	40	8-8-9
7	F	6	3459	40	8-9-9
8	M	8	3005	40	7-9-9
9	M	5	3459	40	9- -10
10	F	2	3941	40	9-9-9
11	M	4	3671	40	8-8-9
12	M	1.5	3572	40	6-7-9
13	M	4	4026	40	6-7-8
14	M	3	3657	38	7-7-8
15	F	5	2750	39	7-8-
16	M	2	4252	41	6-7-8
17	F	2	2877.5	42	8-9-9
18	F	1.5	3033	40	8-9-9
19	M	1.25	3005	38	8-9-9
20	M	1.5	4111	42	8-9-9
21	F	1.5	3118	38	8-8-9
22	M	3	3217.5	38	8-9-9
23	M	4.5	3076	40	8-8-9
24	M	3	3232	38.5	5-7-8
25	M	3	4167	40	8-9-
26	M	3	3728	40	8-9-9
27	M	1.25	3374	38	8-9-9
28	M	1.5	3104	40	9-9-9
29	M	1.25	2948	38	7- -9
30	F	3.5	2835	40	8-8-9
Mean		2.9	3428	40	8-9-9

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[1] F=Female, M=Male.

APPENDIX B

MAXIMUM AND OPTIMUM TEMPERATURE RECORDINGS

MAXIMUM AND OPTIMUM TEMPERATURE RECORDINGS IN THE RECTAL AND AXILLARY SITES[1]

Subject	Maximum Temperature and Time (Minutes')		Optimum Temperature and Time (Minutes')	
	Rectal	Axillary	Rectal	Axillary
1	98.6/1'	98.4/10'	98.6/1'	98.2/6'
2	98.8/3'	99/8'	98.6/2'	99/8'
3	99.2/3'	99.2/4'	99/2'	99/3'
4	99.2/2'	98.8/9'	99/1'	98.6/3'
5	100.4/4'	100.4/6'	100.4/4'	100.2/4'
6	98.8/3'	98.6/6'	98.6/2'	98.4/5'
7	99.4/4'	98.6/4'	99.2/3'	98.4/3'
8	99/12'	98.8/8'	98.8/5'	98.6/3'
9	99/3'	99.2/6'	98.8/2'	99/3'
10	99.4/3'	98.6/2'	99.2/2'	98.6/2'
11	99/3'	98.6/6'	98.8/2'	98.4/4'
12	99.6/1'	99.6/2'	99.6/1'	99.4/1'
13	99.4/11'	99.2/5'	99.2/3'	99/3'
14	99.4/3'	99/3'	99.4/3'	99/3'
15	99/6'	99/9'	98.8/4'	99/9'
16	99/4'	99/9'	98.8/3'	98.8/6'
17	99/3'	99/8'	98.8/2'	98.8/6'
18	98.2/2'	98/9'	98/1'	97.8/5'
19	98.8/2'	99/6'	98.6/1'	98.8/5'
20	99.2/2'	98.8/12'	99.0/1'	98.6/6'
21	99.2/3'	98.8/12'	99.0/2'	98.6/7'
22	99/3'	99/12'	98.8/2'	98.8/6'
23	99.6/2'	99.2/10'	99.4/1'	99/8'
24	98.6/8'	98.6/9'	98.4/4'	98.4/8'
25	99.4/5'	98.4/9'	99.2/2'	98.2/3'
26	99.2/4'	99/4'	99/3'	99/4'
27	98.8/3'	99.2/12'	98.6/2'	99/7'
28	98.6/4'	98.4/10'	98.6/4'	98.2/6'
29	97.6/9'	97.8/8'	97.4/2'	97.6/6'
30	99/4'	98.8/9'	98.8/1'	98.6/6'

[1] Temperatures listed are in degrees Fahrenheit.

APPENDIX C

DIFFERENCES BETWEEN RECTAL AND AXILLARY SITES

DIFFERENCES BETWEEN RECTAL AND AXILLARY SITES IN 30 NEONATES[1]

Subjects	Maximum Temperature	Optimum Temperature
1	.2	.4
2	-.2	-.4
3	0	0
4	.4	.4
5	0	.2
6	.2	.2
7	.8	.8
8	.2	.2
9	-.2	-.2
10	.8	.8
11	.4	.4
12	0	.2
13	.2	.2
14	.4	.4
15	0	-.2
16	0	0
17	0	0
18	.2	.2
19	-.2	-.2
20	.4	.4
21	.4	.4
22	0	0
23	.4	.4
24	0	0
25	1.0	1.0
26	.2	0
27	-.4	-.4
28	.2	.4
29	-.2	-.2
30	.2	.2

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[1] Temperatures are listed in degrees Fahrenheit.

APPENDIX D

PARENT'S CONSENT

PARENT'S CONSENT

Date____________________

Dear Parent:

A study is being conducted by Ms. Linda Hestvik, R.N., pediatric graduate nursing student at the Medical College of Virginia of the Virginia Commonwealth University. This study is to aid nurses in determining relationships between body temperature recordings such as in your child. In this study, each child will have rectal and axillary temperatures taken at the same time. The temperatures will be taken during one visit with your child in the nursery, without costs, injuries, or benefits, and with the hospital's permission. Your child's identity will not be made known in the study and you may withdraw your child from this study at any time.

I, ________________________, give permission for my child, ________________________, to be in Ms. Hestvik's study.

____
(Parent's Signature)

APPENDIX E

DATA COLLECTION CONSENTS

OMMITTEE ON THE CONDUCT OF HUMAN RESEARCH APPROVAL FORMS

O: Ms. Linda M. Hestvik (Dr. Ethelyn E. Exley, Advisor) Principal Investigator

Dr. Margaret Spaulding Chairman of Department Concerned

Dr. Martha B. Conway Administrator of Research Grants & Contracts

ITLE OF INVESTIGATION: Temperature Recordings in Neonates.

VCU ASSIGNED NUMBER: 4/31/80

The Committee on the Conduct of Human Research of Virginia Commonwealth University met on April 23, 1980, and the above investigation was reviewed and approved.

You are cautioned to note that:

1. Informed, written consent is required of each human subject or his legally qualified guardian or next-of-kin, unless specifically excluded.

2. Any deviation from the above named protocol, or the identification of unanticipated problems which may involve risk to subjects, must be reported to this committee for review and approval.

3. Your study is subject to continued surveillance by this committee, and it will be reviewed periodically. The next review is scheduled for April 1981. At that time you must make available to the committee a roster of all subjects, a file of the completed permission slips and a summary of the results obtained, especially any adverse or unexpected effects.

4. All requests for information related to this investigation must include the exact title, the investigator, and the VCU Study Number as noted above.

5. This investigation has been indentified as being submitted to the Department of Health, Education and Welfare, and will be certified to H. E. W.
Yes ______ NO __X__

6. In some instances approval is contingent upon compliance with changes designated by the committee. If such are imposed, they are listed on an attached sheet, one copy of which must be signed and returned to the committee to indicate the investigator's acceptance of the changes. Where there is no attachment, the study was accepted.

[redacted]

Donald L. Brummer, M.D., Chairman,
Committee On The Conduct of Human Research

DLB /ad

(Revised Form Dated 5/1/76)

Director of Nursing s Consent

Date July 28, 1980

Dear Mrs. Barth:

A study is being conducted by Ms. Linda M. Hestvik, R.N., pediatric graduate nursing student at the Medical College of Virginia of the Virginia Commonwealth University. This study will determine relationships between body temperature recordings at various sites in thirty neonates. Each neonate in the study will have simultaneous rectal and axillary temperature recordings made. The recordings will be made during one visit with the neonates in the nursery and with parental consent.

I hereby consent that Ms. Hestvik may observe and record temperatures in neonates the Medical College of Virginia Hospitals.

[redacted]

(Director's Signature)
(Acting Director)
(P.B. Cushnie, RN)

Approved by [redacted]

VITA

[redacted]