CHANGES IN BASAL BODY TEMPERATURE AND THE ONSET OF LABOR

by

Diana P. Selvey

A thesis submitted to the faculty of
The University of Utah
in partial fulfillment of the requirements for the degree of

Master of Science

College of Nursing

The University of Utah

August 1983

THE UNIVERSITY OF UTAH GRADUATE SCHOOL

SUPERVISORY COMMITTEE APPROVAL

of a thesis submitted by

Diana P. Selvey

This thesis has been read by each member of the following supervisory committee and by majority vote has been found to be satisfactory.

Chairman: Lorraine Sevcovic, C.N.M., M.S.

T. Kelii Sine, C.N.M., Ph.D.

Maeona K. Jacobs, R.N., Ph.D.

THE UNIVERSITY OF UTAH GRADUATE SCHOOL

FINAL READING APPROVAL

To the Graduate Council of The University of Utah:

I have read the thesis of Diana P. [redacted] in its final form and have found that (1) its format, citations, and bibliographic style are consistent and acceptable; (2) its illustrative materials including figures, tables, and charts are in place; and (3) the final manuscript is satisfactory to the Supervisory Committee and is ready for submission to the Graduate School.

[redacted]
Date

Lorraine Sevcovic, C.N.M., M.S.
Member, Supervisory Committee

Approved for the Major Department

Linda K. Amos, Ed.D., F.A.A.N.
Chairman Dean

Approved for the Graduate Council

James L. [redacted]
Dean of The Graduate School

ABSTRACT

The presence of a change in basal body temperature (BBT) before the onset of labor was tested by analyzing BBT charts. Eighty-two women agreed to participate and were instructed in the proper measurement and recording of oral BBTs during the last five weeks of pregnancy. Comments were recorded daily for any factors affecting BBT existed. The data analysis was done on all valid charts returned, (25 of 28). Eight of the 25 charts showed isolated BBTs that dropped significantly (∠0.5° F) below the baseline, but no pattern linked those charts. CUSUM analysis showed no significant drop in the baseline BBT at any time during the final 21 days before labor. The findings suggest that BBT can not be used as a predictor of the onset of labor in humans.

CONTENTS

ACKNOWLEDGMENTS

This thesis was a rich and rewarding experience thanks to the help and guidance of several individuals. I wish to thank Lorraine Sevcovic M.S., CNM for introducing me to Caron Campbell's research on BBTs and then providing support, direction and leadership as my committee chairperson. Kelii Sine, CNM, PhD, and Maeona Jacobs RN, PhD directed me towards greater logic, precision and accuracy in my work, which improved the quality of the research appreciably. Special thanks are in order for Dave Jones who designed the program for my VIC-20. This programming was done out of interest in the research, after his wife agreed to participate in the data collection.

Caron Campbell assisted immensely in the initial literature review by sharing many of the articles and library searches she had done for her thesis. This kindness was truly appreciated for the frustration, time and money it saved.

Most importantly a special thanks must go to Michael Selvey: my typist, breadwinner, husband and most loyal supporter. Without his assistance and encouragement, this thesis would have been much more difficult to complete.

CHAPTER I

INTRODUCTION AND REVIEW OF LITERATURE

A decrease in basal body temperature (BBT) several days before the onset of labor has been identified as a consistent finding in the study of many species of domesticated animals. Very few late pregnancy records of basal body temperature (BBT) in humans have been analyzed, and widely varying conclusions have been reached concerning the patterns. Systematic study is needed to evaluate the pattern of late pregnancy basal body temperature (BBT) in humans. If such a study identified a specific temperature drop before the onset of labor, it could be used as a predictor, and would enhance prenatal care as well as having far reaching effects.

Accurate prediction of labor could assist birth centers and hospitals in planning staffing and supply needs much more accurately. More complete and up to date prenatal records could be available at the birth site. Care providers would have the ability to plan adequate backup for potentially busy periods, while scheduling more time off during quiet periods. The benefit to expectant families would be great. They could plan for the event with greater ease, so that the baby items were ready, pets would be fed, older children cared for, and out-of-town visitors would arrive at a convenient time. With major worries out of the way they could enter labor relaxed, well-nourished, well-rested and prepared.

Prenatal management of prematurity and postmaturity would also be enhanced if BBT could be identified as a predictor of labor. Women at risk for prematurity could maintain BBT recording and possibly begin tocolytics even earlier than they are presently started, avoiding major changes in cervical dilation. Conversely, in cases of postmaturity where the temperature chart heralded impending labor, artificial induction of labor with its inherent risks and added costs might be avoided.

The reliable prediction of the onset of labor has far reaching economic, sociological, psychological and medical ramifications.

The underlying questions of this study became more obvious after looking at the conceptual framework on which they are based. The theories concerned with the onset of labor generally note that multiple mechanisms, occurring simultaneously, with accelerating effect will eventually result in the onset of labor. Danforth (1977), Freedman (1974) and Pritchard (1979) describe eight mechanisms or theories of the onset of labor which include: increased uterine distension, increased levels of prostaglandin F_2, relaxation of the lower uterine segment, decreased progesterone dominance, increased estrogen influence, increased free intracellular calcium, release of arachidonic acid, and an increase in fetal pituitary and adrenal activity. The mounting effects of these mechanisms cause physiologic responses that can be identified as signs and symptoms of impending labor. All mammals to some extent will exhibit identifiable signs including: relaxation of pelvic muscles, decreased abdominal tone, i.e., "drop" of the uterus, increased ease in palpation of the fetus, heavy mucous discharge from vagina, mammary enlargement and increased secretory activity, vulvar swelling and loosening, restlessness or nesting behavior, loss of appetite, production of loose or runny stools, and a drop in BBT.

Some signs and symptoms are more easily identified and quantified than others, for example beginning cervical effacement and dilation versus restlessness and nesting behavior. Some signs and symptoms have species specific measurability as in lengthening of the sacrosciatic ligament in cattle, or vulvar loosening in dogs. Those signs and symptoms that can be consistently identified and measured within a species, and occur consistently before the onset of labor have been identified as predictors. Basal body temperature has been tested as a predictor in cattle, dogs, goats, sheep, swine, primates and now in humans with varying results. It is the most easily measured of the identified predictors, therefore has the greatest utility in a general population if proven reliable as a predictor in humans.

Before studying the relationship between BBT and the onset of labor, an understanding of BBT and what affects it is necessary. BBT is the measurement of heat produced by the body at rest. Body temperature reflects the body's metabolic rate therefore BBT is measured at a time when the body's metabolic rate is the lowest during the day. BBTs show characteristic diurnal patterns with an average peak at 3-7 p.m. and nadir at 3-7 a.m. The hours of peak and nadir readjust as a reflection of the individual's daily activities, shiftwork and normal meal schedule.

Normal patterns may be upset by long distance travel and variable shiftwork. Males and nonovulating females will maintain a consistent BBT pattern, showing only diurnal variation. Ovulating females demonstrate a very characteristic biphasic pattern of preovulatory low BBTs with elevated ovulatory BBTs. Failure of the BBT to fall to its preovulatory low is the first sign of pregnancy (Greenhill & Freedman, 1974).

There are many physiologic responses that can effect BBT, by first effecting the basal metabolic rate (BMR) of the body. The intake of food and the subsequent digestive processes cause a rise in basal metabolic rate (BMR) for 12-14 hours. Ingestion of liquids causes a change in surface temperature of tissue contacted by the fluid, but in usual quantities will not greatly elevate the basal metabolic rate (BMR). Muscular activity has the greatest effect on BMR and exogenous heat production. Any muscular activity at all will elevate the BMR. Sympathetic nervous system stimulation, i.e., emotional responses, result in the release of epinephrine and norepinephrine and elevation of the BMR. A calm, relaxed, unemotional atmosphere is necessary to minimize this response. The BMR will also elevate in response to ambient temperatures in an attempt to maintain a stable internal body temperature. Minimal BMR response occurs in ambient temperatures of 65-80° F. Sleep, providing rest and minimized external stimulation is necessary to get a true reading of the body's resting metabolic rate. A minimum of eight hours of sleep is normally required to reach the BMR, but in late pregnancy this is an unrealistic expectation, due to maternal discomfort, urinary frequency and fetal activity. Five hours of uninterrupted sleep is considered acceptable in the woman near term, to minimize the effects of sympathetic and muscular activity.

There are also physiologic responses to abnormal processes that will cause an elevation in BMR. Prolonged malnutrition and dehydration cause a break-down in body tissue, elevating the BMR. Febrile response to inflammation and infection will raise the BMR. Brain lesions, especially those growing in the region of the hypothalamus can effect the regulation of body temperature, changing the BMR. Since thyroid hormones are intimately involved in the regulation of the BMR, hyper-or hypothyroid conditions will effect BBTs. Persons functioning within 10-15% of normal will exhibit a BMR and BBT within normal limits. Women with thyroid function outside these limits have a greatly decreased fertility rate and are rarely able to carry existing pregnancies to term (Pritchard & MacDonald, 1977). The ingestion of toxins, most commonly, inhaled toxins in cigarette smoke, cause an increase in BMR and may falsely elevate the BBT by heating mouth tissue that will come in contact with the thermometer.

Because of the many factors that exist to elevate BBT, accurate measurement is more difficult than might be immediately suspected. The oral BBT thermometer was originally designed for use in identifying the phases of the menstrual cycle. It is calibrated in one-tenth degree increments, rather than two-tenths to allow greater accuracy in measurement. The characteristic ovulatory rise in BBT is much more easily identified with this type of thermometer. Erickson (1980) identified variation among types, brands and models of thermometers great enough to lead to error in the clinical assessment of patients. This error can be controlled by using the same device for the same client day to day. If a thermometer must be replaced, this should be noted on the client's record. Erickson noted in the same study that there is a 0.3° F. difference between temperatures taken in the anterior and posterior sublingual pockets, the posterior pocket registering higher, more accurate temperatures due to its richer blood supply

Traditionally the oral BBT has been taken using a three to five minute measuring period. Erickson demonstrated than an eight minute period was necessary to allow rewarming of surrounding skin tissue cooled by the thermometer on insertion. The thermometer should be shaken down before going to bed, then placed safely within reach at the bedside before going to sleep, to avoid undue activity or environmental temperature changes before taking the temperature in the morning. For this same reason the alarm clock or radio should be placed within reach if they are to be used. During the measuring period the client must remain in bed and somnolent. The whole procedure must be the very first thing done in the morning after awakening. If the client got up during the night, had a snack, was unable to sleep or had intercourse, a note should be made on the record as these could cause a rise in the BBT. Erickson also noted that spurious readings might occur in the presence of inhalation therapy, nasogastric tubes, intestinal tubes, lower dentures, mouth breathing or total absence of teeth. Properly done, oral BBTs are as accurate as esophageal, tympanic and central blood temperature readings.

Review of the Literature

Most human research relating BBT to the reproductive cycle has centered around fertility-controlling pregnancy so that it occurs at wanted times, and finding out why it does not occur or continue when it is planned. Jacobi in 1876 identified premenstrual and postmenstrual phase temperature patterns and was followed in 1905 by Van de Velde who linked the phases with probable fertility and described the typical temperature curve in greater detail. By the 1940s, contraceptive research was considered much more acceptable and ethical. A flurry of studies identified intermenstrual bleeding, intermenstrual pain, increased vaginal secretions, changes in libido and change in BBT as indicators of ovulation. During the 1950s the trend continued. New information evolved as some BBT charts were accidentally continued by fertility clients after conception and unstable patterns were found to be consistent with early pregnancy loss. Follow-up on this during the next decade identified specific patterns for specific problems. Benjamin, in 1960, evaluated seven pregnancy BBT charts done by clients not participating in his fertility clinic and found an elevation in BBT continuing for 13-14 weeks, with a gradual decrease to the preovulatory level by the 23rd week, continuing there until delivery. He evaluated only seven charts because "Patients become so keen and interested and conscientious about taking their temperatures that harm may come of it psychologically. Usually, therefore, patients are not allowed to continue with the recordings once the desired information is obtained" (1960, p. 180). This may have been the prevailing opinion because there was not reported research concerning BBTs and late pregnancy. Though Vollman supervised the recording of 30,000 menstrual cycles in 650 women, including their periods of pregnancy, the data have not been analyzed for a shift in BBT relating to the onset of labor. Vollman suggested BBT charts as a way to identify the date of conception, estimated date of confinement, identify early pregnancy loss, and identify the return of ovulation after delivery.

Keyser, Iffy and Cohen (1975) again noted unstable and erratic BBT patterns in pregnancy that were associated with first trimester abortion and in tubal pregnancies. Stable patterns were directly correlated with continuation of pregnancy. Yewlett (1979) reports observation of a 0.5° F. drop in her own BBT four days before the spontaneous onset of labor in her second pregnancy. After noting a decline in BBT before delivery in monkeys, Good (1981) reviewed the charts of a group of hospitalized women at term and identified no drop in temperature before delivery. In light of the multiple uncontrolled variables that effect most hospitalized women, and the multiple instruments normally used for taking temperatures, these results are not conclusive. No other research relating BBT and term pregnancy in human subjects has been identified except a study done by Campbell in 1981. Of the 19 temperature records evaluated, nine showed a drop in BBT occurring at varying times before the onset of labor. An additional nine records showed only erratic patterns, and five records were incomplete due to early delivery. Several problems existed within the methodology. First, the subjects were instructed to take temperatures for five minutes. Increasing the interval to eight minutes would improve the accuracy by eliminating false lows. Second, no instructions were given regarding the placement of oral thermometers. Consistently taking posterior sublingual BBTs would remove false lows and possibly reduce the number of erratic patterns. Third, the starting date at 37 weeks gestation was not early enough to allow for 21 days of recording before a term birth at 38 weeks, since normal variation of term is 38-42 weeks gestation. Beginning recording at 35 weeks would decrease the losses due to "early" term births. Fourth, the use of vaginal temperatures for some participants resulted in an extremely low compliance rate (3:11), and multiple studies have proven oral BBTs equal in accuracy to any other route if properly done. Fifth, statistical techniques are presently available for reinterpreting temperature data that is erratic due to variable data collection times. Keeping these changes in mind, this creative and unique study can be used as a basis for further research relating BBT to the onset of labor in humans.

BBT has been the basis for predicting labor in domestic animals for many years. Weisz's 1943 review of the literature is cited as the spring board for most studies done after that time. In interpreting the results of BBT studies in animals, the usefulness of the predictor was evaluated according to assumptions that are not applicable to a human population. Researchers many times reported their results as negative because they were looking for a single temperature value that could be used as a marker to signal impending labor. Frequently the variation in temperature from animal to animal was too great to allow one distinct temperature to be identified as a predictor. In dealing with large herds, many researchers found individual temperature charts too cumbersome to maintain, so mean herd temperatures for each testing time were calculated. Taking temperatures in a basal state was nearly impossible for most animal researchers, so temperature patterns frequently appeared erratic due to spurious values caused by excitement, food ingesting, activity and ambient temperatures.

In spite of the many problems, a trend is obvious in reviewing the literature, and that is the consistent fall in BBT before the onset of labor. Further evaluation of this pattern necessitates a species by species critique of some of the more important findings.

Weisz (1943) noted that swine maintain a subnormal temperature for the last eight days before labor which will rise again immediately before labor begins. King, Willoughby, and Hacker (1972) confirmed that the subnormal temperature will last at least eight days before labor ensues. In 1978, Hendrix, Witzel, Gaskins and Bendel noted that the temperature rise begins 4-12 hours before labor with a mean elevation of 0.4° F. Littledike, Witzel and Riley (1979) improved upon the methodology used in 1978 and noted a 1.4° F. increase in temperature that began at 12 hours prior to delivery.

Weisz (1943) described a gradual rise in temperature in pregnant sheep that continues to the physiologic maximum, then shows a rapid fall, not exceeding the physiologic minimum, immediately prior to the onset of labor. Using this study as a starting point, Eubanks (1969) studied temperature changes in parturient sheep and noted a decline of 1.3° F. over 54 hours immediately before the onset of labor. Winfield, Makin and Williams (1973) tightened the control over variable ambient temperatures and showed an average fall in BBT of 0.9° F. over 48-72 hours prepartum. These patterns seem significant for human research but were rejected as too difficult for sheep herders to use because diurnal variation in temperatures, being as great as the labor predictive change in temperatures, begin to occur as the temperature measuring is being done on a large herd. Use of this predictor also would mean keeping extensive records on each animal. Since sheep are bred to lamb in the early spring and are kept outside, ambient temperatures probably are a tremendous detriment to BBT as a useful labor predictor.

In Weisz's 1943 review of the literature he states that the rapid fall in BBT prior to labor is an excellent predictor in goats. Jones and Knofton (1971) tested this and were able to identify no prognostic temperature or uniform pattern of temperatures that occurred prepartum in goats. They recorded the temperatures of each goat tested on one daily chart, looking for a general shift in physiologic ranges and mean temperatures. This technique of temperature analysis has been rejected in human research because of the volume of information lost during statistical analysis.

Weisz also described a distinct prepartum temperature pattern in cattle. The cattle show a gradual increase in BBT during the final four weeks of pregnancy, then a fall of 1.6° F. is noted one day before calving. Dufty (1971) noted that Weisz's information referred to dairy cattle so a study was designed to test BBT as a labor predictor in beef cattle. Individual temperature charts were kept and a decrease in BBT of 0.2-0.9° F. was noted after the BBT had reached its maximum point two to four days before calving. Dufty suggested using a constellation of predictive signs to make the diagnosis of imminent labor.

Earlier research in late pregnancy BBTs in dogs was directed towards the well being of the family pet or protecting valuable breeding stock; consequently individual temperature records were evaluated by many researchers. Weisz states that the prepartum temperature drop is 2.2-3.2° F., occurring over the last three to four days, followed by a rapid rise in temperature as labor begins. Recently, temperature records have been used to enable gnotobiotic researchers to time laboratory deliveries. Gnotobiotic dogs are delivered by Cesarean section into a sterile environment and raised in this environment on sterile food. Litter loss is normally 25-50% without colostrum intake and additional loss from prematurity is high if the pups are delivered as much as a day or so early. The need for an accurate labor predictor is obvious. Greismer and Gibsen (1963) mention that a drop in BBT is only one of the predictors they use to presage impending labor. Long, Mezza, and Krakowka (1978) identified a consistent decrease in BBT less than 24 hours prior to labor. They cited this as a confirmation of the Concannon, Powers and Holder study (1977) in which 78 of 80 dogs exhibited a prepartum fall of 1.5° F. plus-or-minus 0.2° F.

A study of 32 _Macaca nemestrina_ monkeys done by Ruppenthal and Goodlin (1981) described a dramatic fall in body temperature to levels below the normal physiologic range in all the laboratory animals one to two hours prior to delivery.

In summary, the research on basal body temperature and impending labor indicates several important trends. A general pattern of temperature decline before the onset of labor exists throughout the animal kingdom. This decline is identified by taking daily temperatures in the basal metabolic state and evaluating individual temperature charts, rather than looking for group mean temperatures which might be predictive of the onset of labor.

Research Questions

1. Will improvements made in data collection methods increase the proportion of women with a significant drop in BBT before the onset of labor?
2. Will a significant drop in BBT before the onset of labor occur in an identifiable pattern?

Assumptions

1. Accurate BBTs can be measured and recorded by research subjects after proper instruction.
2. A labor predictor identified in multiple species of lower animals may also be a valid labor predictor in humans.

CHAPTER II

METHODOLOGY

Definitions

Basal Body Temperature (BBT)

Basal body temperature (BBT) is conceptually defined as the measurement of heat produced by the body at complete rest, resulting from basal metabolic activity. For the purpose of this study, BBT was operationally defined as the oral temperature taken for eight minutes immediately upon waking, after a minimum of five hours sleep and before the initiation of any other activity.

Onset of Labor

Onset of labor was defined as regular uterine contractions that cause dilation of the cervix and resulted in the delivery of the infant. For this study the onset of labor was defined as occurring when the uterine contractions reach sufficient frequency, intensity and duration to bring about readily demonstrable changes in the effacement and dilation of the cervix. This was validated by health care personnel through the use of a cervical examination, and resulted in the birth of a child within 36 hours.

Sample

One hundred volunteers were sought from local childbirth preparation classes. This population was selected because of the high compliance level demonstrated by this group. Women who stated they had one of the following problems had a rotation made on the researcher's copy of the consent form but were still included in the study: thyroid disease which required treatment, history of a brain tumor, prolonged rupture of the fetal membranes, infection currently requiring antibiotics, lower dentures, or any chronic disease. Volunteers were identified at 34 weeks gestation and were given a date at 35 weeks gestation when they began daily BBTs. At the time of volunteering, they were taught to read their basal body thermometers and demonstrated the ability to read and record the temperatures accurately. They were given free thermometers, directions for use, temperature charts, a stamped addressed return envelope and a copy of their informed consent form to take home. Broken thermometers were replaced from the same lot, by the investigator free of charge to the volunteers. A notation on the chart was made if a second thermometer was used. Thermometers used in this study were kept by the subjects. Volunteers that were excluded from the study were those who cannot understand English adequately to follow the data collection instructions, and those who were unable to read and record temperatures accurately at the time of instruction.

Instruments

Basal body thermometers supplied at manufacturer's cost from Becton-Dickinson (catalogue #4130) were used. Adequate performance and lack of gross defect were verified by the researcher and subject during the instructional period. Calibration was assumed by the company and not repeated by the researcher.

Data Collection

Oral basal body temperatures were taken and recorded daily beginning at 35 weeks gestation, on a date identified by the researcher, and ending with the delivery of the infant(s). Before going to bed the subject would shake down the thermometer and place it at the bedside in a safe place, within easy reach. At the moment she awakened in the morning, she placed the thermometer in the right or left posterior sublingual pocket and allowed the thermometer at least eight minutes to register. Mouth breathing was minimized. During the time the temperature was taken she remained somnolent to assure an accurate basal reading. After at least eight minutes the thermometer was read taking the lowest number that the mercury bar reached. This was recorded in the proper data column by drawing a dot on the line which corresponded to the temperature. (An illustration was included in the subject's directions.) In the column for that data, a comment was made if there was less than five hours uninterrupted sleep before the temperature was taken, if there was more than the normal uterine or fetal activity overnight, any signs of illness, unusual vaginal discharge, or anything the volunteer might have thought was important. The time the temperature reading was done was noted directly under the date. The researcher was available by phone to answer any questions and to make arrangements to replace broken thermometers.

Completed charts were mailed to the researcher's home address. These records were then evaluated for acceptability. Criteria for rejection included induction of labor, Cesarean section before the onset of labor, and records with multiple missing recordings during the final 21 days. Significant drops in temperature were identified using the CUSUM technique with the decision interval defined as 0.5° F. Any temperature elevation of 0.9° F. above the last few temperatures was considered a febrile response even without a notation by the subject. Any charts with identifiable drops in BBT were compared to identify specific temperature patterns that occurred before the onset of labor.

CHAPTER III

ANALYSIS OF THE DATA

During the analysis phase of this research, returned charts were evaluated for usefulness according to preset criteria and five charts were rejected for data analysis. Rejection occurred most often due to incomplete charts (See Table 1). Postcards were mailed out by the researcher before data analysis began, requesting the return of all charts, complete or incomplete, if the infant's delivery had taken place. A total of 23 charts was analyzed. Initial analysis included rejecting data which were spurious, calculating a mean temperature for the final 21 days of each chart (excluding the day of delivery) and reviewing the charts for significant low BBTs occurring during the test period. Spurious data was defined as any temperature 0.5° F. or greater than its neighboring temperatures. Individual temperature elevations associated with comments that indicated a nonbasal state were also considered spurious and rejected. Charts containing significant BBT drops (0.5° F.) numbered eight out of 23 and their patterns are

Table 1

Charts Rejected for Analysis

Code Number	Reason for Rejection
#79	Delivery before 21 days of charting
#54	Cesarean section before the onset of labor
#17	Quit charting
#18	Erratic chart without comments (unable to interpret)
#9	Broken thermometer -- not replaced

described in Table 2 as method number one.

A second method for chart analysis, the CUSUM test, was also used. This is an accepted statistical test adapted for identifying significant temperature shifts from a baseline, when the pattern is erratic. The test identifies a baseline by taking the mean of the first seven valid readings, then the computer program signals a significant shift in subsequent BBT means. The performance length of a CUSUM test, that is, the number of temperatures to be analyzed, must be finite. An infinite run would eventually result in a false signal of a significant shift. To obtain useful data then, the run was limited to 21 days.

The CUSUM test is performed as follows: sample values x_1, x_2, x_3, ... x_n of a random variable are obtained. Detecting a downward shift of the mean E(X) below a baseline B is desired. If E(X) B then the negative deviations predominate and a significant change in BBT is signalled. The significant change in E(X) is $\delta\sigma$ where σ = var(x). A hypothesis test is applied where the null hypotheses H_0: $E(X) \geq B$ is tested against H: $E(X) = B-\delta\sigma$. The CUSUM is calculated as cumulative deviations of the same BBT values x_r about $B-\frac{1}{2}\delta\sigma$, which is the central reference

Table 2

Charts with Significant (∠ 0.5° F.) Drops

in BBT Identified by Method #1

Code Number	Day before Delivery	Amount of Drop
#4	1	0.8° F.
#10	8	0.5° F.
#11	7	0.5° F.
#41	5	0.6° F.
#44	19	0.7° F.
#45	1	0.5° F.
#45	3	0.6° F.
#48	1	0.5° F.
#48	8	0.5° F.
#50	6	0.6° F.

point.

The arithmetic version is:

S_1 = CUSUM derived from the sample value x

$S_o = 0$

$S_r = \max(0, S_{r-1} + x_r - B - \frac{1}{2}\delta\sigma)$, $r = 1, 2, \ldots x$

H_o rejected: $S_r < h\sigma$.

The critical value of H was calculated to yield a significant level of x = .05. The magnitude of $\delta\sigma$ was set at 0.5° F.

CHAPTER IV

RESULTS

Identifying sample drops in BBT by comparing daily BBTs to a calculated mean resulted in eight of the 23 charts (34%) showing significant drops. These changes occurred at varying times: three of the eight charts showed a drop at one to three days before delivery, five of eight dropped at five to eight, and one chart demonstrated a drop at 19 days before delivery (see Table 2). The temperatures that dropped more than three days before delivery returned to near baseline, rather than maintaining at a new, lower baseline as demonstrated in the animal literature (see Figure 1). Method #2, using the CUSUM method, was designed to identify changing baselines in erratic charts. This method identified none of the 23 charts to have significant baseline changes at 0.5°, 0.4°, or 0.3° F.

Using all 23 charts, a frequency polygon was constructed to illustrate the range of deviation in degrees Farenheit from the baseline that occurred

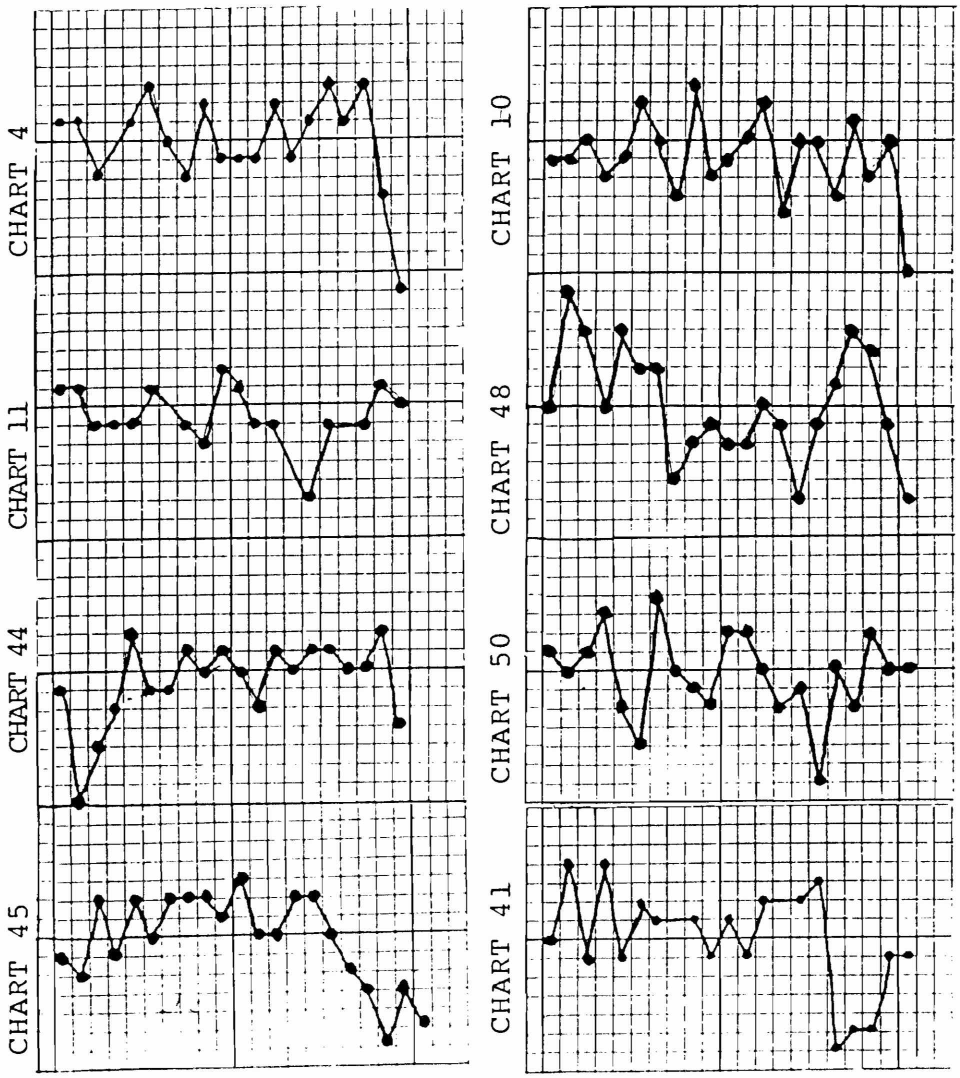


Figure 1. Charts containing significant drops in BBT.

each day (see Figure 2). The mean of the daily deviations was also illustrated. Using the frequency polygon, it is obvious that the BBT in late pregnancy remains essentially stable, varying around a baseline temperature probably in response to individual stimuli within each woman.

Research Question One

Research question one stated:

> Will improvements made in data collection methods increase the proportion of women with a significant drop in BBT before the onset of labor?

The research clearly demonstrated that controlling for the variables that effect BBT and the measurement of BBT results in fewer spurious temperatures, more accurate charting, and the demonstration of no change in the baseline temperatures before the onset of labor.

Research Question Two

Research question two stated:

> Will a significant drop in BBT before the onset of labor occur in an identifiable pattern?

The patterns recorded by participants demonstrated their responses to other identifiable variables affecting their basal metabolic states. No overall shift

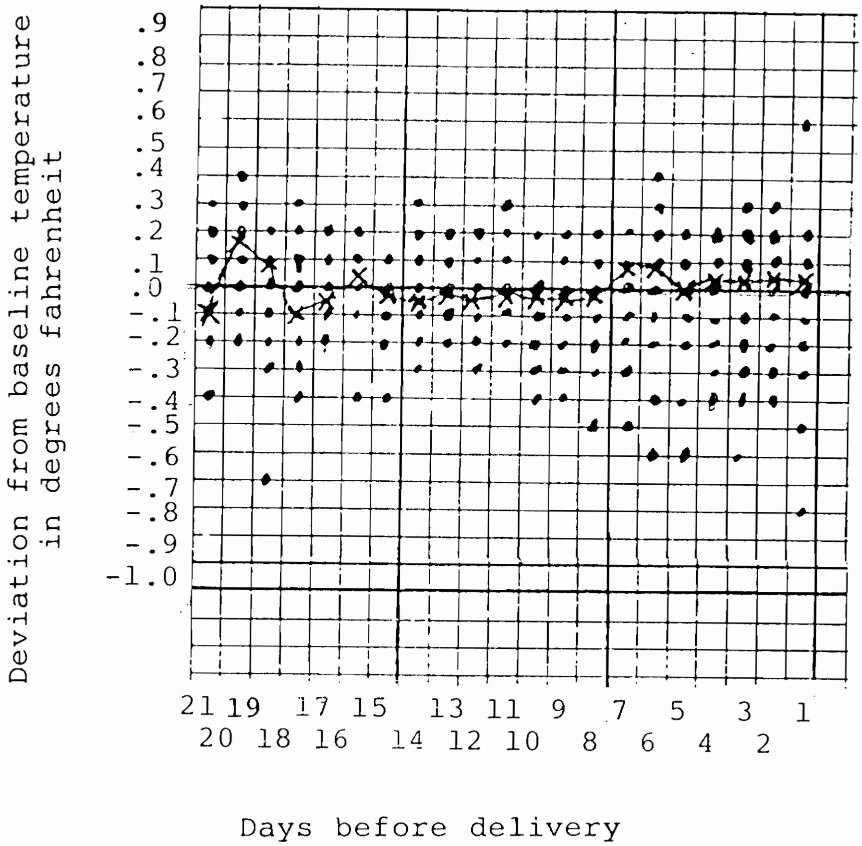


Figure 2. Frequency polygon. ● = individual deviation from baseline temperature in degrees fahrenheit. X = mean deviation in BBT from the baseline (n = 23).

in basal temperature occurred, so the pattern was that of late pregnancy -- varying around a mean.

CHAPTER V

DISCUSSION

Probably the most interesting results of this study were found not in the statistical evaluation of the charts, but in the comments received from participants. The volunteers had been taught how to take BBTs that were accurate by controlling for variables that would increase metabolic rate, i.e., indigestion, lack of sleep, muscular activity, emotional stimulation, infection, and chronic disease. They were instructed to write comments when true basal conditions did not exist, but to take their temperatures anyway. These comments resulted in some very interesting observations. Most importantly, women in late pregnancy may never reach a true basal or resting metabolic rate.

One of the first requirements for reaching the basal state is adequate rest, defined as at least five hours of unbroken sleep. Rarely did anyone sleep this long. The most common thing that interrupted their sleep was urinary frequency. Very few women reported nights with less than two trips to the bathroom, with two to six trips being the usual range reported. The rare night of unbroken sleep usually was associated with a "significant" drop in BBT the next morning. In addition to urinary frequency, fetal activity awakened many of the participants. This activity was more uncomfortable closer to delivery, probably due to increasing fetal size in a confined space. Vivid dreams that awakened and frightened the women were also frequently reported. Due to urinary frequency, fetal activity, bodily discomforts and vivid dreams, few if any women ever achieve a true basal metabolic state.

One further observation recorded by one-half of all the participants in this study was the occurrence of URI symptoms: sore throats, colds, bronchitis and nasal congestion. The significance of this finding is difficult to interpret in view of the number of charts involved and the occurrence of seasonal allergies at the time of recordings. This might be an interesting symptom to include if studying the "miseries of late pregnancy."

At the same time that the participants learned about BBTs, basal metabolic rates and the skills necessary to take part in this study, the researcher shared the comments made by Dr. Benjamin in 1960. This physician had done early pregnancy BBT chart analysis and commented in his research that continuing BBT charting through pregnancy might be psychologically harmful to the patient. Many of the participants in the present study responded to these comments at the time they mailed back their charts. The common theme of their comments was that the charting helped them recognize, accept and pleasantly anticipate the rhythm of their bodies' responses to late pregnancy. Their comments demonstrate the introverted focus of thought processes common in late pregnancy. Rubin(1961) described this introversion as a developmental task of late pregnancy. Necessary for reviewing past experiences with pregnancy and parenting, Rubin considered the evaluation and integration of these past and present experiences as a developmental task that must be completed before sucessfully entering a new birth and parenting experience. Charting BBTs and comments, then, might be interpreted as being psychologically useful for some women.

In view of the finding that women in late pregnancy rarely achieve basal metabolic levels, further research into finding a predictor of the onset of labor in humans might be directed towards examining signs and symptoms that occur simultaneously would be more useful than single phenomenon research. The results of the Campbell study coupled with this investigation suggest that even if a change in metabolic rate and BBT does occur before the onset of labor in humans, serial waking temperatures will not isolate the pattern. A completely different detection method probably has to be used, taking into account the variables identified by this study. Further research in detection might be directed towards:

1. Developing a different tool to identify the drop in BBT, and

2. Developing and testing a tool to identify other late pregnancy signs and symptoms that might be used as predictors of the onset of labor.

APPENDIX

INFORMED CONSENT, INSTRUCTIONS TO PARTICIPANTS AND BASAL TEMPERATURE RECORD

Informed Consent Form

1. This research study is being done to identify changes in basal body temperature and relate them to the onset of labor. Each individual taking part will be asked to take her temperature each morning, beginning at 35 weeks gestation and ending when she delivers her baby. Temperatures will be taken on a basal body temperature thermometer, and at the completion of the study, participants may keep their thermometers. Thermometers broken during the study will be replaced by the researcher at no charge to the participant.

2. Discomforts or risks: The temperature must be taken immediately upon awakening and the thermometer must remain in the mouth for 8 (eight) minutes. The participant will be instructed on how to record the temperatures. The procedure will take 10 minutes per day.

3. Benefits: If a pattern can be identified between a change in temperature and the onset of labor, future expectant parents could use this technique to plan for when their infant would deliver. This research will not affect the participants during this pregnancy.

4. Confidentiality: All temperature records are coded with a number that matches the consent form. Confidentiality of the records will be maintained- the Food and Drug Administration maintains the right to inspect these records.

5. Any questions regarding this research, the rights of the participant, or related matters should be directed to Diana Selvey, telephone number 322-4830. Participation in this study is voluntary, and withdrawal from this research may occur at any time without penalty. The thermometer need not be returned.

____

Participants Signature	Name and Address (Please print)

Instructions to the Participant

Thank you for participating in my study! Basal body temperature is the body's temperature at complete rest. The most accurate temperatures occur after 5 hours of sleep, taken at 5:30 a.m. to 11:00 a.m. and read after the thermometer has been in the back pocket under your tongue for 8 minutes.

Please follow these instructions:

1. Shake down the thermometer before going to bed and place it by your bed.

2. In the morning before doing anything, take your temperature. Place the end in the pocket or indentation that is under the back of your tongue. Leave the thermometer in for 8 (eight) full minutes.

3. Reading the temperature, record it on the chart and read it again to be sure you wrote down the right temperature.

4. If for some reason your sleep was interrupted or you slept less than 5 hours, make a notation under comments for that day. Try to note anything you think might be important, for example;

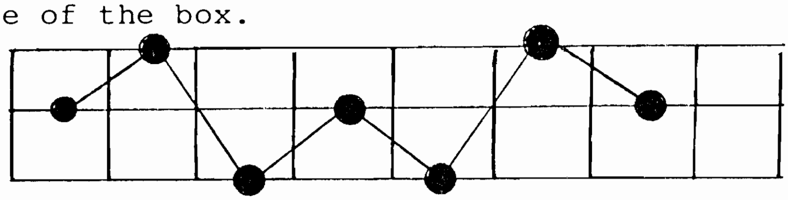
    a. Up to bathroom
    b. Any medications other than iron and vitamins
    c. Fever or illness

5. Thermometers may be cleaned with alcohol or soap and cold water. Generally, all you need to do to clean the thermometer is wipe it with a tissue. Please store it in the box it came in, as it is fragile.

6. If you have any questions or something happens to your thermometer, please feel free to call me (Dinny Selvey) at 322-4830.

Instructions for Charts

1. To record temperature for each day, place a solid dot on the line for the temperature, in the middle of the box.



2. Begin charting on the date written at the top of your chart.

3. Write any comments in the long column below the day's temperature.

4. When you deliver, please answer the questions below and mail the answers with the chart back to me:

Diana P. Selvey
817 South 5th East
SLC, Utah 84102

Please circle and fill in correct answers:

1. Regular frequent contractions that were confirmed as true labor by internal, cervical exam began at ______________AM/PM on ____________(date).

2. My labor was induced on ____________(date) at ______________AM/PM.

3. My bag of waters broke spontaneously/was broken artificially (circle one) at ______________AM/PM on ____________(date).

4. My son/daughter was born on ____________(date) at ______________AM/PM.

Basal Temperature Record

Code # ______ Begin charting on ________

Date
Time
9
8
7
6
5
4
3
2
1
29 0
9
8
7
6
5
4
3
2
1
28 0
.9
.8
.7
.6
.5
.4
.3
.2
.1
97.0
COMMENTS

REFERENCES

Abrams, R.M. Some properties of rectum and vagina as sites for BBT measurement. Journal of Fertility and Sterility, March 1981, 35 (3), 313-316.

Beggs, A.R. & Campion, E.J. Proceeds for the Australian Society for Animal Production, 1966. 6, 169.

Benjamin, F. BBT recording in gynecology and obstetrics. Journal of Obstetrics and Gynecology of the British Empire, 1960, 67, 177-187.

Campbell, C.C. Changes in basal body temperatures and the prediction of the onset of labor. Unpublished master's thesis, University of Utah, 1982.

Concannon, P.W., Powers, M.E., Holder, W., & Hansel, W. Pregnancy and parturition in the bitch. Biology Reproduction, 1977, 16, 517-526.

Dufty, J.H. Determination of the onset of parturition in Hereford cattle. Australian Veterinary Journal, March 1971, 47 (3), 77-82.

Ewbank, R. The fall in rectal temperature seen before parturition in sheep. Journal of Reproduction and Fertility, 1969, 19, 569-571.

Goodlin, R.C. Personal communication. November 19, 1981.

Guyton, A.C. Textbook of medical physiology (4th ed.). Philadelphia: W.B. Saunders Company, 1971.

Griesemer, R.A. & Gibson, J.P. The gnotobiotic dog. Laboratory and Animal Care, August 1963, 13 (4), 643-649.

Greenhill, J.P. & Freesman, E.A. Biological principals and modern practice of obstetrics (13th ed.). Philadelphia: W.B. Saunders Company, 1974.

Hartman, C. Science and the safe period. Huntington, New York: Robert E. Krieger Publishing Company, 1972.

Hendrix, W.F., Kelley, K.W., Gaskins, C.T. & Bendel, R.B. Changes in respiratory rate and rectal temperature of swine near parturition. Journal of Animal Science, 1978, 47 (1), 188-191.

Jones, D.E. & Knifton, A. Assessment of time of onset of parturition in goats by means of daily recording of rectal temperatures. The Veterinary Record, September 1971, 89 (11), 300-302.

King, G.J. Willoughby, R.A. & Hacker, R.R. Fluctuations in rectal temperature of swine at parturition. Canadian Veterinary Journal, March 1972, 13 (3), 72-74.

Littledike, E.T., Witzel, D.A. & Riley, J.L. Body temperature changes in sows during the periparturient period. Laboratory and Animal Science, October 1979, 29 (5), 621-624.

Long, D., Mezza, R. & Krakowka, S. Signs of impending parturition in the laboratory bitch. Laboratory and Animal Science, April 1978, 28 (2), 178-181.

Patterson, R.E. Personal communication, October 30, 1982.

Pritchard, J.A. & MacDonald, P.C. Williams obstetrics (16th ed.). New York: Appleton-Century-Crofts, 1980.

Royston, J.P. & Abrams, R.M. An objective method for detecting the shift in basal body temperature in women. Biometrics, June 1980, 36, 217-224.

Royston, J.P. The adjustment of BBT to allow for time of waking. British Journal of Obstetrics and Gynecology, December 1980, 87 (12), 1123-1127.

Rubin, R. Basic maternal behavior. Nursing Outlook, 1961, 9, 683.

Ruppenthal, G.C. & Goodlin, B.L. Body temperatures of Macaca nemestrina during pregnancy and parturition. American Journal of Primatology, 1981 1 (3) (abstract) 329.

Weisz, L. The temperature phenomenon before parturition and its clinical importance. Journal of the American Veterinary Medical Association, 1943, 102, 123.

Williams, P.T. Use of the BBT graph in habitual aborters. Texas Journal of Medicine, 1959, 55, 287-291.

Winfield, C.G., Makin, A.W. & Williams, A.H. Prediction of the onset of parturition in sheep. _Australian Veterinary Journal_, December 1973, _49_, 549-553.

Vollman, R.F. _The menstrual cycle_. London: W.B. Saunders Company, 1977 (Volume 7 in the series "Major Problems in Obstetrics and Gynecology").