Circadian Effects on
Basal Body Temperature Graphs in
Women Night Workers

by

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Chapter I

Just as the environment has daily rhythmical fluctuations such as sunrise, sunset, and tidal changes, so do human beings. These daily fluctuations are referred to as circadian rhythms (meaning circa, about, and die, day). Throughout evolution human beings have been affected by and have consequently adapted to the circadian variations in the environment as demonstrated by their tendency to work during the daylight hours and to sleep at night. As society has grown in complexity, factors have developed that necessitate variation in human schedules from the environmental rhythms. With the current boom of high technology, more individuals will be faced with schedules that vary from the environmental rhythms in order to maximize resources (Naisbitt, 1982). Czeisler (1982) reported that 26.8% of the work force in the United States is exposed to major changes in their day/night patterns as a result of night or shift work.

With more people working shifts that vary from the natural environmental rhythm, nursing must respond by studying the effects of such schedule changes on the physical and psychosocial aspects of health. Working the night shift causes a reversal of the natural schedule which has many potential effects on the individual's life, from alteration of sleep schedules and eating patterns to interruption of social relationships.

Because of these potential effects on the individual's life, much research has focused on different aspects of night work. Night shift workers as a group have been studied for the subjective characteristics of fatigue and feelings of well being and the objective characteristics of absenteeism and productivity. The physical parameters of urine excretion, urine composition, blood pressure, pulse rate and body temperature rhythms have also been studied. The majority of this research has been done on men who were subjected to periods from 3 days to 6 weeks of night time work rather than on individuals whose consistent lifestyle involved night shift work (Folkard, Monk, & Lobban, 1978).

As women have moved from traditional roles to the work force, women have also been involved in night shift work. Nurses, primarily female professionals, are an example of a work force whose nature necessitates a night shift. For women night workers, one physiologic component which may have significant circadian consequences is the menstrual cycle. However, no studies of the impact of night shift work on the menstrual cycle have been reported.

The basal body temperature (BBT) graph is a useful clinical tool for measuring menstrual regularity and ovulation. In working with women who use the BBT graph to predict ovulation, either as an adjunct to contraception or as a means of promoting conception, it is important to know what impact night shift work has on basal body temperature graphs. This study examined the BBT graphs of night shift workers to determine the validity of basal body temperature as a predictor of ovulation in this population.

Review of Literature

The basal body temperature (BBT) is defined as an oral temperature taken after at least four hours of undisturbed sleep. It is used in reproductive studies to determine fluctuations in temperature in women that accompany changes in hormonal levels during the menstrual cycle. This variation is used clinically to predict ovulation. (It is important to note that, though named "basal body temperature", the clinical BBT graph does not reflect a truly basal state in the individual.) In addition to temperature variation during the menstrual cycle, body temperature fluctuates in a daily rhythmical pattern. Women who work the night shift have altered circadian temperature rhythms which may consequently alter their monthly basal body temperature patterns making the BBT graph a less reliable indicator of ovulation (Folkard et al., 1978; Rutenfranz, Colquhoun, Knauth, & Ghata, 1977; VanLoon, 1963). This review of the literature considers circadian rhythms generally, circadian temperature rhythms, basal body temperature graphs during the menstrual cycle, the effects of night shift work on the individual in general and the effects of night shift work on circadian temperature rhythms as they apply to the problem of prediction of ovulation through basal body temperature graphs.

Human Circadian Rhythms

As human beings have adjusted to the 24-hour day, their internal physiologic rhythms have become synchronous (entrained) with the environmental rhythms. Body temperature, sleep-wakefulness, muscle coordination, renal function, and endocrine system function all demonstrate approximate 24-hour rhythms each day (Sollberger, 1965; Wever, 1983; Bunning, 1973).

In order to determine if these rhythms are endogenous or exogenously caused by the environment, researchers have examined individuals placed in isolation settings without windows or clocks. The results of these studies led to the conclusion that human circadian rhythms are endogenous and usually slightly longer than 24 hours. In addition, human circadian rhythms are usually synchronized with one another meaning the periods are of approximately equal length and the peaks and troughs coincide to some degree (Wever, 1983).

Normally, circadian rhythms are entrained to periodic factors in the environment which are called zeitgebers (time givers). The light-dark periodic factor is one of the most powerful zeitgebers in animals, but social (activity of society), cognitive (awareness of clock time) and perceptual (detection of changes in levels of light) factors are more powerful zeitgebers in human beings (Rutenfranz et al., 1977).

When all environmental cues are removed, circadian rhythms persist having periods of 23-27 hours. Such rhythms without environmental cues are called free running. One problem with free running rhythms is the loss of synchrony as different rhythms assume endogenous rhythms with periods of different lengths. This is evident when individuals are placed in continuously dark environments and their sleep-wake cycle has a period of 28 hours and their temperature rhythm has a period of 25 hours (Wever, 1983).

Entrainment to new zeitgebers, such as occurs when an individual travels across time zones, is called phase shifting. In interpreting changes in rhythms, phase shifts must be differentiated from masking effects of other factors on the true rhythm. Sleep has this masking effect as body temperature decreases approximately 0.4 C (0.7 F) whenever an individual sleeps and increases whenever an individual becomes active regardless of other zeitgebers (Aschoff, 1982; Wever, 1983).

Endogenous oscillators control a variety of overt circadian rhythms. There are 2 basic human oscillators with different degrees of persistence, or oscillatory strength; the body temperature oscillator and the activity oscillator. Under normal conditions, these two oscillators are synchronized causing synchrony of the overt rhythms in the individual. The oscillator concept is significant in understanding changes in the temperature rhythm because the temperature oscillator is particularly persistent with a period of 25 hours. When changes are made in the light/dark cycle, the sleep/wake cycle, or mealtimes, the temperature rhythm persists with a period of approximately 25 hours.

Obvious changes in the temperature rhythm must be closely examined for masking effects because, due to the strength of the oscillator, the temperature rhythm is not likely to change (Wever, 1983). These concepts of basic human circadian rhythms are essential for an understanding of the circadian temperature rhythm and the impact of night work on that rhythm.

Circadian Temperature Rhythms

A diurnal variation of temperature is well described in the literature with the earliest studies attributed to Geirse in 1842 and Davy in 1845. They observed that oral temperatures were low upon awakening, rose until midmorning, remained stable until evening and started to fall at bedtime (Minors & Waterhouse, 1981). The circadian temperature rhythm (Figure 1) is a sinusoidal oscillation with a trough, or nadir, at approximately 0400 hours and a peak from 1500 to 2300 hours (Aschoff, Fatranska, & Gereke, 1974; Cebanac, Hildebrandt, & Massonnet, 1976; Conroy & Mills, 1970; Elliott, Mills, & Minors, 1972; Mills, 1966; 1968; Felton, 1975). As previously stated, sleep causes a decrease in temperature and may alter the configuration of the circadian temperature rhythm curve if sleep occurs before the peak of the cycle (Minors & Waterhouse, 1981).

Methods of circadian temperature rhythm measurement have progressed from the initial studies using periodic oral temperatures (Minors & Waterhouse, 1981) to periodic rectal temperatures, skin temperatures, and urine stream temperatures (Brooke, Collins, & Fox, 1973; Akerstedt, 1977; Colquhoun, Blake, & Edwards, 1968; Folkard & Monk, 1989; Ilmarinen, Ilmarinen, Korhonen, & Nurminen, 1980; Leonard, 1980; Minors, Mills, & Waterhouse, 1976; VanLoon, 1963). Recently, the development of continuous recording devises that are small enough to be conveniently carried by subjects have allowed continuous measurement of rectal, vaginal, or skin temperatures without interrupting normal daily activity (Smith, 1980; Romanczyk, Crimmins, Gordon, & Kashinsky, 1977; Denny, Kinzie, Sack, & Lewy, 1982; Vokac, Magnus, Jebens & Gundersen, 1981; Mills, Minors & Waterhouse, 1978; Henane, Buguet, Roussel & Bittel, 1977).

Circadian Temperature Rhythms in Night Shift Workers

When individuals are subjected to schedules in opposition to the environmental and social rhythms around them, changes occur in their

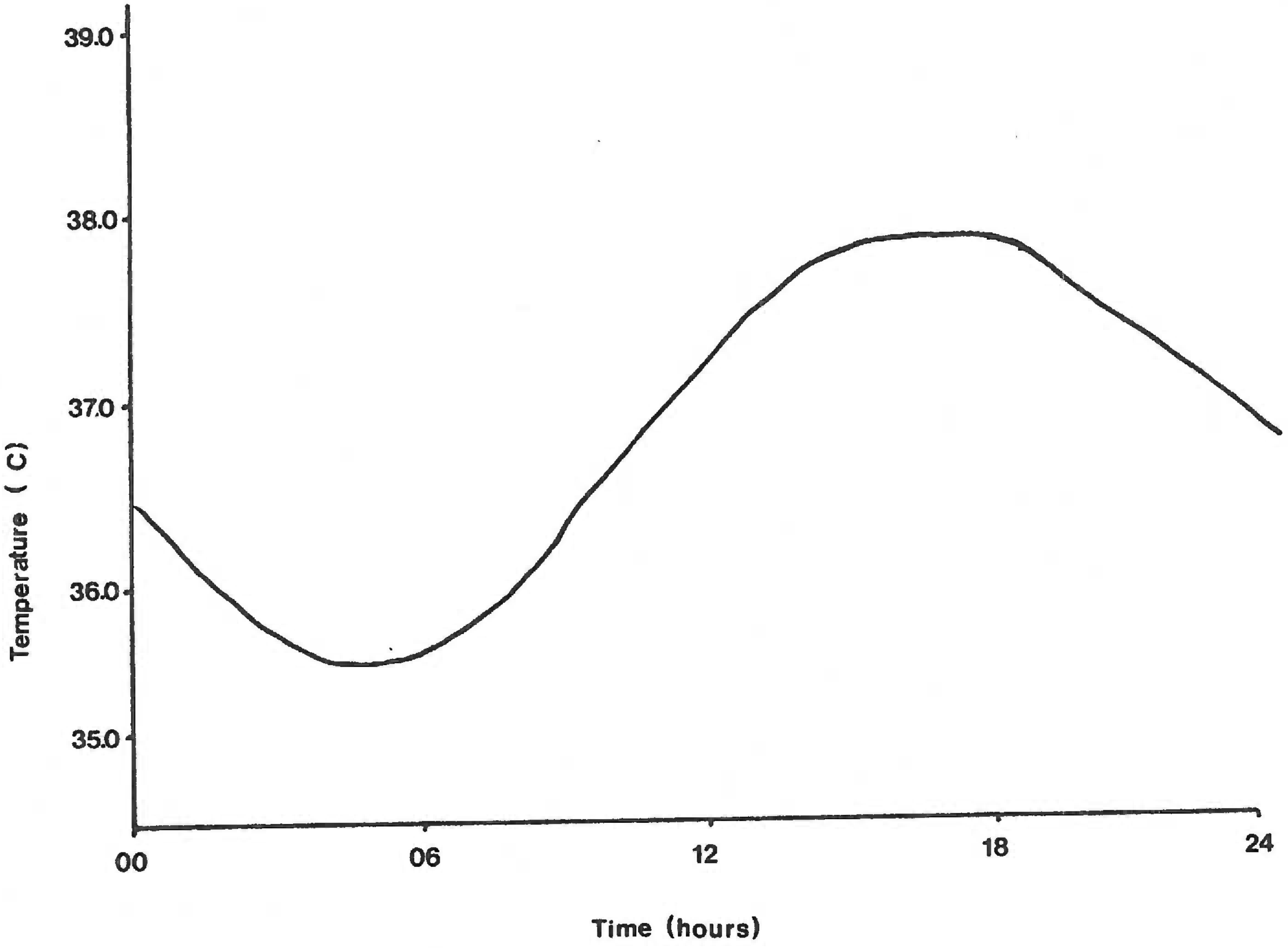


Figure 1. Circadian temperature rhythm.

circadian cycles. Research on temperature rhythms of subjects on altered sleep/wake cycles falls into 2 catagories, laboratory studies and field studies. Laboratory studies are typically carried out in controlled environments, such as hospitals or sleep laboratories, on volunteer subjects who are not normally subjected to altered schedules. Field studies have been done using volunteer night workers during their normal routine.

Laboratory studies

VanLoon (1963) studied 3 "healthy young men not used to night work" who worked 13 weeks of night work. Oral temperatures were taken every 4 hours while awake during the week prior to night work, the first 6 weeks of night work, the 13th week of night work, and the first week after returning to day work. The average night shift temperature rhythm for the entire period of night work showed a moderate fall at night, no rise in the morning, a slight fall with sleep, and a clear rise in the afternoon. In summary, the curve was flatter than the normal sinusoidal circadian rhythm of body temperature. The workers showed quicker adaptation to the night curve the longer on nights and a persistent reversal to a day shift pattern on weekends off. The length of the study and the use of a "typical" night shift schedule are strengths of this study. A limitation of the study is the lack of specific definition of the temperature measurement procedure including the conditions under which the temperatures were taken. Because the conditions are not clearly defined, it is unclear whether any of the temperatures were taken under the conditions previously defined for basal body temperature graphs.

Knauth and Ilmarinen (1975), Ilmarinen et al. (1980), and Colquhoun et al. (1968), all found similar results with subjects working periods of night work from 12 days to 3 weeks. In all of these studies, the rhythm of subjects performing night work and sleeping during the day showed a flattened curve (Figure 2).

Knauth and Rutenfranz (1976) studied four subjects who worked initially on a day shift and then worked 21 days on a night shift. The curve of rectal temperature was normal during the control days and remained unchanged during the first day of night shift. On the following days, the trough of the cycle slowly drifted toward the end of sleep time while the time of peak temperature did not change throughout the study (Figure 3). The author explained this change as "masking" because the sleep-wake cycle affected the circadian fluctuation. The stability of the cycle peak is cited as evidence that the circadian temperature cycle remains but the period of sleep alters the trough.

Limitations of these studies include the use of periodic temperature measurement, the use of non-night workers, and the arbitrary schedules of 12 to 21 days of continuous night work. Temperature rhythms determined by periodic temperatures taken while awake are less reliable than rhythms determined by 24-hour continuous monitoring. Volunteers unaccustomed to night work may demonstrate adaptation to night work that is different than individuals whose lifestyle includes night work. Rarely do night workers work schedules of 12 to 21 nights of continuous work. More typically, full time

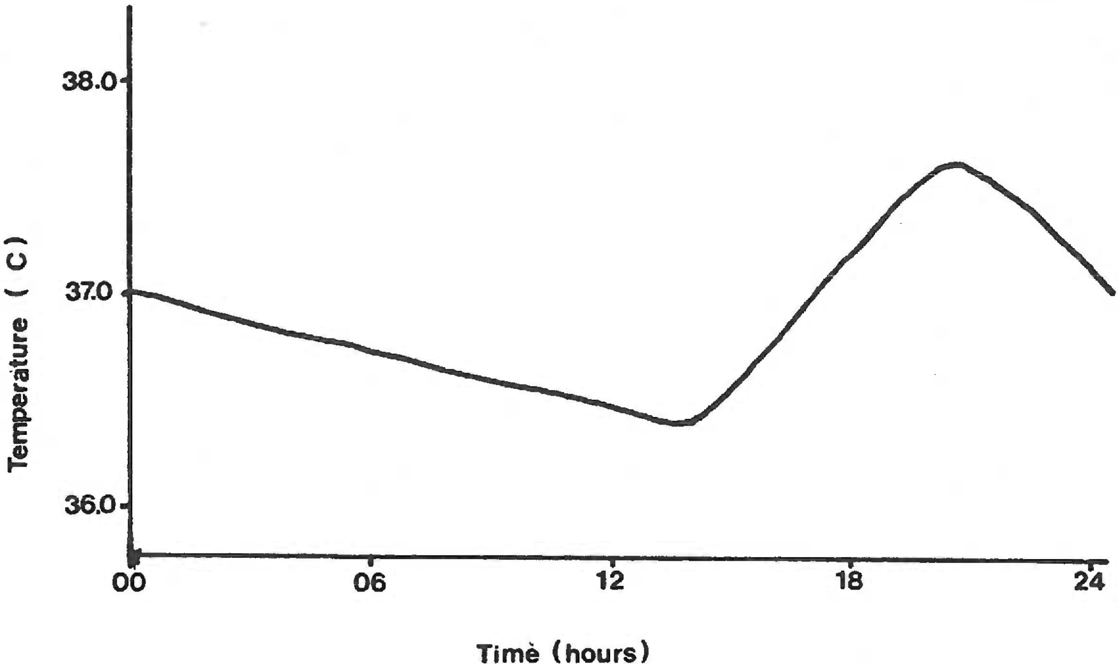


Figure 2. Flattened circadian temperature rhythm of night workers.

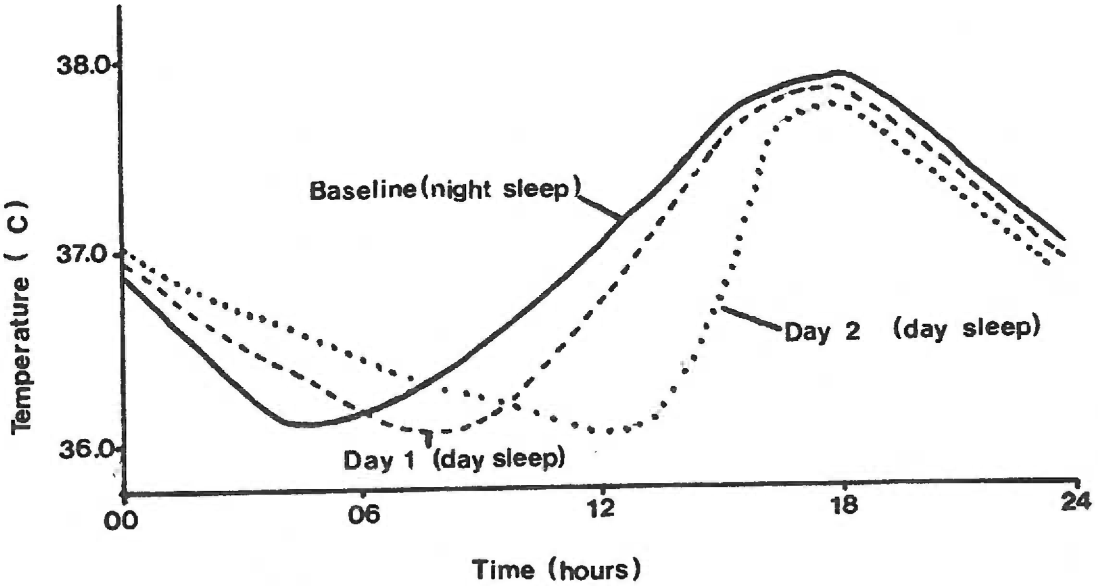


Figure 3. Masking of the circadian temperature rhythm by sleep.

night workers work from 4 to 10 nights followed by 2 to 6 nights off. Research on the effects of night work on circadian rhythms should reflect typical night shift schedules.

Field studies

Studies by Folkard et al. (1978) and Reinberg, Vieux, Ghata, Chaumont, and Laporte (1978) on full time night shift workers demonstrated flattened temperature rhythm curves similar to the laboratory studies. Folkard et al. (1978) studied 20 night shift nurses, 10 full time and 10 part time, for oral temperature curves and subjective feelings of well being in an attempt to discern differences in adjustment between the two groups. The length of the study was 4 nights, consecutive work nights in full time nurses and 2 nights on 2 occasions in part time nurses. In addition to flattened temperature rhythms, the results showed the circadian temperature rhythm changed over a period of successive nights, and there was no significant difference in temperature adjustment between full time and part time nurses. The only significant difference between the groups was a more positive sense of well being in the full time group which was attributed to a greater degree of scheduling their lives toward night work. The study is limited by the use of periodic temperature measurements and by differences in age and length of time on the night shift between the groups. Both age and length of exposure to altered schedules affect adaptation (Aschoff,1968; Conroy & Mills, 1970).

The circadian temperature rhythms of night shift workers were studied by Felton (1975) in a prospective study of 39 volunteer nurses over the course of 18 consecutive days. The testing period included 3 dayshift baseline days, 5 days on night shift, and 10 days post-night shift where the subjects returned to a daytime schedule. Body temperature, urinary excretion of potassium, sodium, and creatinine, and urine osmolality were tested every three hours while awake. Prior to night shift, body temperature showed characteristic circadian variations which were low in the early morning and rose during the day to reach a mid afternoon maximum before beginning to decline. When adapting to night shift, the body temperature cycle advanced 3 hours, moving the peak and the trough ahead by 3 hours, after a one day lag. After 5 days, the time of the cycle peak had not returned to the pre-night shift baseline. Though this seems to contradict previously reported studies, it is difficult to compare these results to the results of other studies because only the cycle peak and not the entire rhythm was evaluated for return to the pre-night shift baseline. The time of the cycle peak is influenced by a variety of factors, such as activity levels, making it a less reliable indicator of rhythm normalcy than the entire rhythm or the cycle nadir. Another limitation of the study was a lack of clarity about data collection methods.

Felton (1970) conducted a similar study on the effect of time cycle change on body temperature and blood pressure in young women. The time cycle change examined was the annual spring change to Daylight Savings Time. The sample included 32 junior and senior nursing students who were observed before and after the time change. Methods for both blood pressure and temperature measurement were clearly defined. Results demonstrated a one hour shift in schedule is not enough to alter the normal temperature circadian rhythm.

In summary, both experimental and field studies on the effects of night work on circadian temperature rhythms show similar results. When exposed to night work over a period of days, the circadian temperature rhythm flattens. Upon return to daytime routine, the rhythm returns to the normal circadian rhythm of body temperature on the first day. Even after 21 days on continuous nights, the temperature rhythm did not resemble the normal dayshift rhythm with a phase shift. Given this alteration of the normal rhythm during night work with a return to normal rhythm on days off, one might expect difficulty in interpreting BBT graphs when temperatures are taken at different times of day due to different times of awakening throughout the cycle.

Basal Body Temperature During the Menstrual Cycle

Before discussing research on body temperature during the menstrual cycle, it is important to review basic menstrual physiology. There are two phases of the menstrual cycle, the follicular phase when an ovum develops in preparation for release at ovulation, and the luteal phase when the corpus luteum prepares to support a fertilized egg. The events of the follicular phase include rising estrogen levels, proliferation of the uterine endometrium, and growth of the follicle. At the end of the follicular phase, there is a dramatic rise in lutenizing hormone (LH) with a concommitant but less pronounced rise in follicle stimulating hormone (FSH). This so called LH surge stimulates the ovary to release the egg (ovulation).

During the luteal phase, the now-empty follicle becomes the corpus luteum. The corpus luteum secretes both estrogen and progesterone, the latter serving as the major sex hormone of the luteal phase. Without implantation of a fertilized egg in the uterus, corpus luteal function begins to diminish and progesterone levels begin to fall, stimulating sloughing of the endometrium (menstruation). Numbering of days in the menstrual cycle begins with the first day of menses and proceeds to the day before the next menses begins. These events are summarized in figure 4.

Body temperature changes during the menstrual cycle were first reported by Van de Veld in 1904 (Tompkins, 1944) when a rise in temperature of 0.1 to 0.3 degrees Fahrenheit was consistently noticed around the 14th day of the menstrual cycle. Since this initial work, the validity of basal body temperature measurement as a predictor of ovulation has been repeatedly demonstrated (D'Amour, 1943; Martin, 1943; Greulich and Morris, 1941; Harvey and Crockett, 1932; Williams, 1943; Rubenstein, 1940; Zuck, 1938). A standard measure of basal body temperature throughout this research has been oral or rectal temperatures taken upon awakening; before arising, eating, drinking or smoking. Current practice further stipulates the woman must have slept for at least 4 hours. It should again be clarified that, although this temperature is called basal, it does not reflect a truly basal metabolic state. A truly basal temperature would have to be taken under the defined conditions exactly at the time of the thermal nadir.

The typical BBT curve (Figure 5) is described as biphasic with an established baseline during the follicular phase, a rapid rise just after ovulation, maintenance of the high level during the luteal

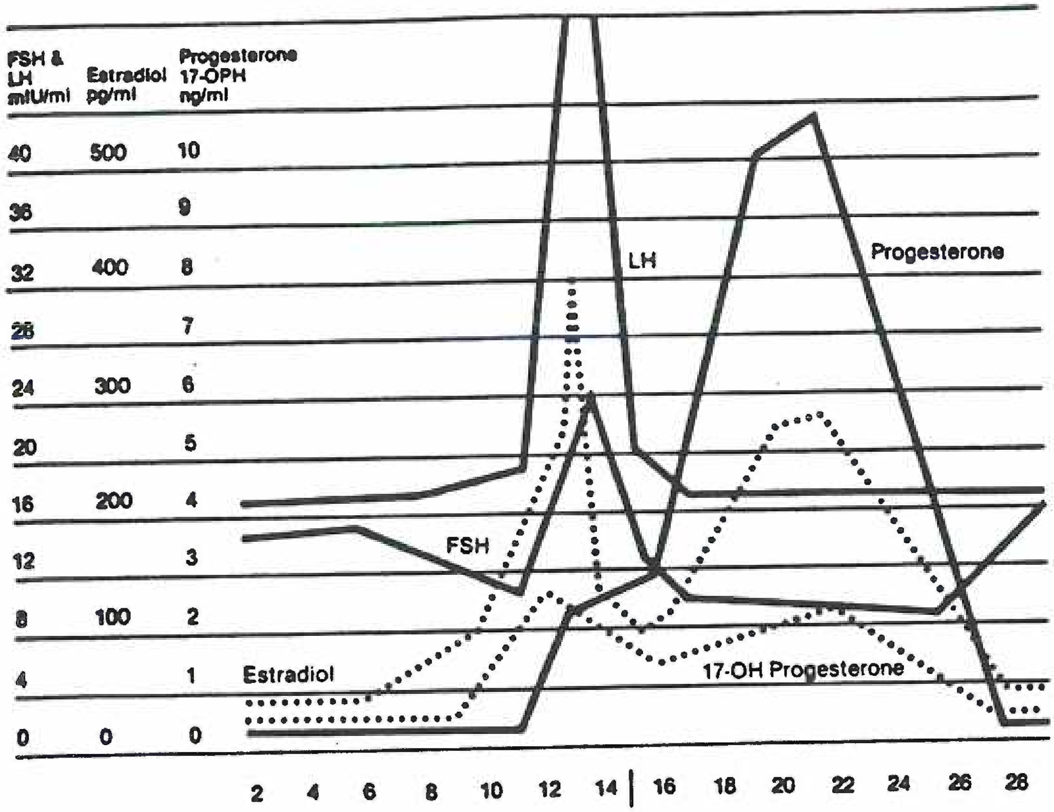


Figure 4. Hormonal variation in the normal menstrual cycle (Speroff et al., 1983, p. 81).

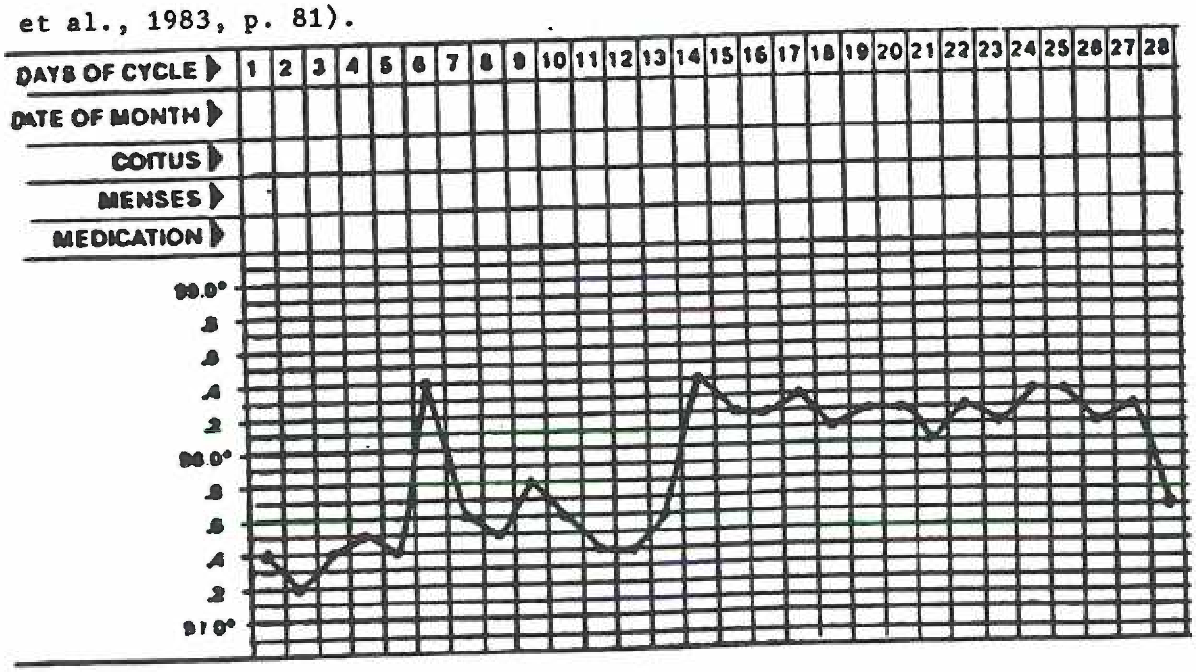


Figure 5. Basal body temperature graph.

phase, and a rapid fall just prior to the onset of menses. This rise is postulated as a rough bioassay of progesterone levels with the temperature rising as progesterone levels rise and falling as progesterone levels fall (Burry, 1984; Hilgers & Bailey, 1980).

Moghissi, Syner & Evans (1972) studied 10 ovulating women to assess the interrelationships between systemic, hormonal, and reproductive tract changes during a normal menstrual cycle. Blood and urine samples, vaginal smears, and cervical mucus were obtained daily from day 10 to day 20 of the cycle and every 2 days during the rest of the cycle. Endometrial biopsies were done at the onset or immediatly prior to the onset of menstruation. Oral basal body temperature was recorded daily throughout the cycle. Methods for obtaining samples and measuring parameters were clearly defined in the study. Basal body temperature was found to rise simultaneously with the LH surge and continued to rise to a significant level 2 days after the surge. This rise correlated closely with the rise in serum progesterone. Furthermore, the maintenance of the higher temperature and subsequent decline in temperature prior to menses also closely correlated with progesterone levels.

In a similar project, Lundy, Lee, Levy, Woodrugg, Wu, & Abdalla, (1974) studied eight women who were planning tubal surgeries by collecting blood samples and measuring rectal basal body temperatures daily throughout one cycle. Tubal surgeries were performed at varying intervals from 1 to 12 days post LH surge at which time endometrial and corpus luteal biopsies were taken. The blood samples were analyzed for plasma estrogen, progesterone, FSH, and LH. Thermal nadir was examined as an indicator of ovulation and the nadir was found to occur prior to ovulation. Histologic changes in the corpus luteum correlated closely to changes in basal body temperature. In summary, both studies demonstrated a correlation between BBT changes and hormonal assays. The BBT was shown to be an effective marker of ovulation.

Interpretation of basal body temperature graphs

Several authors have challenged the reliability of basal body temperature graphs as an indicator of ovulation citing a higher incidence of monophasic graphs than anovulatory cycles in a normal population (Moghissi, 1976; Hilgers and Bailey, 1980; Bauman, 1981). Comparing the documented incidence of anovulatory cycles by hormonal assay to the demonstrated incidence of monophasic charts, these authors question the reliability and clinical utility of the basal body temperature graph. Responding to this controversy, McCarthy and Rockette (1983) noted the lack of a consistent method for BBT graph interpretation in the literature. Their study compared 3 methods for interpreting BBT graphs by evaluating each graph by all 3 methods to determine which method correctly identified the chart as either monophasic or biphasic. Though no attempt was made to varify ovulation with hormonal assays, the large number of charts reviewed (8,496) and the correlation with cervical mucus changes lend credibility to the results. Since no preselection of charts for completeness or quality was done, some charts had to be excluded due to missing readings and temperatures taken under "disturbed conditions" or illness.

The final sample consisted of 5,210 charts on 1,376 women. A comparison of the temperature averaging method, the coverline method, and smoothed curve method were presented. The temperature averaging method is defined as follows:

> (1) The average of the first n temperatures is computed; (2) the thermal shift is identified as soon as consecutive temperatures are a specified amount above this temperature average for a specified number of days; and (3) if no shift is identified, the chart is identified as monophasic. (p. 642)

This method was then evaluated for the optimal rise in temperature and the optimal number of days of sustained rise for evaluative purposes. These values were shown to be 0.3 F for 3 days.

The coverline method is defined as follows:

> (1) A coverline is drawn 0.1 F above the highest of the first n temperatures; (2) a shift is identified when the (n + 1)th temperature is above the coverline and the next 2 consecutive temperatures are on or above the coverline; and (3) once the temperature shift is identified, the day before the shift (the nth temperature) is the PDO (predicted day of ovulation). (p. 642)

The smoothed curve is:

> obtained by replacing the temperature at the ith point, with the average of the the three temperatures at points i - 1, i, and i + 1. The thermal shift is located where the "smoothed" curve transects the average of all temperatures, and all points on the curve remain above this average. To declare a chart biphasic, we

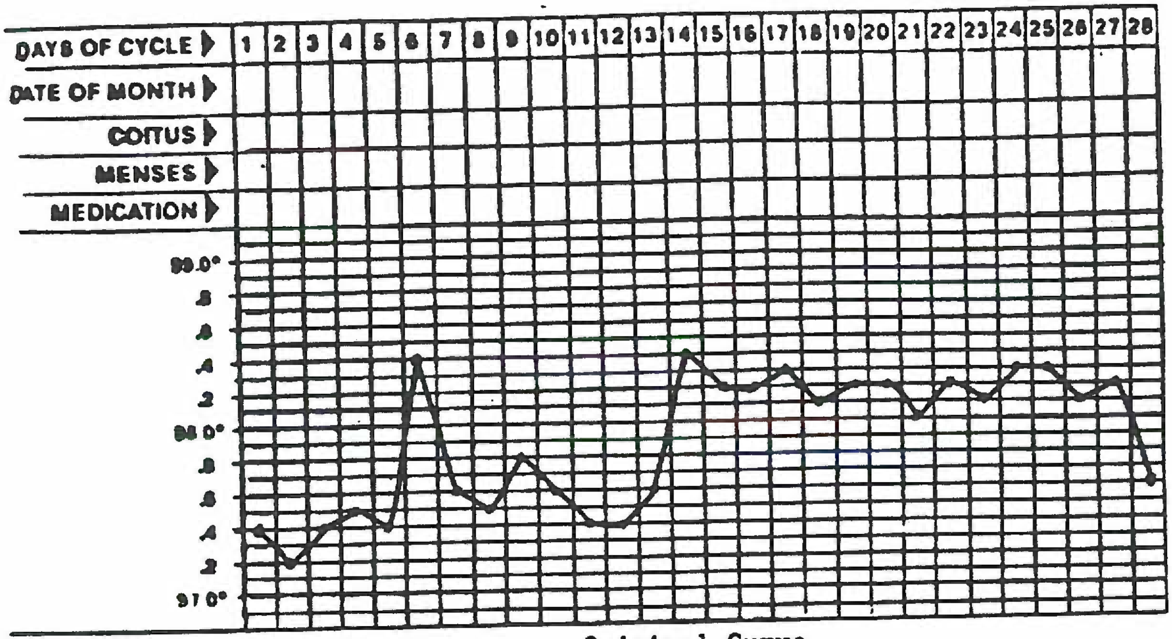
> have required at least 7 points in the postovulatory phase. (p. 642) (See Figure 6 for illustration of the smoothed curve method.)

Temperatures taken during the first four days of the menstrual cycle and during illness were omitted.

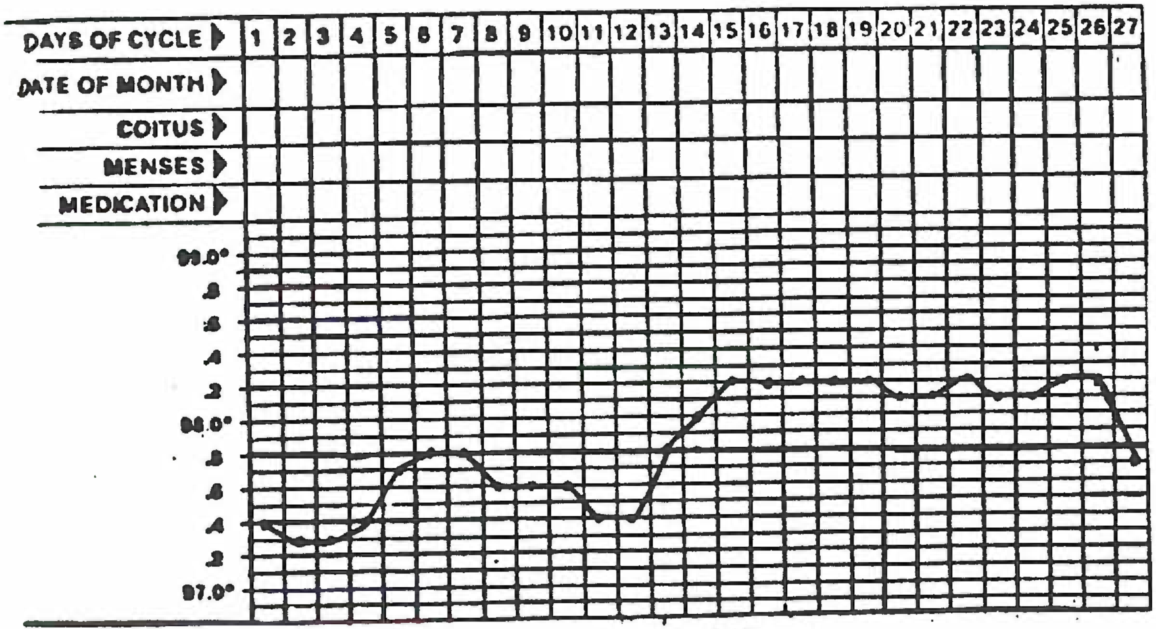
The results of the different analysis methods were compared to cervical mucus changes as recorded by the subjects on the charts and to a statistically predetermined incidence of anovulatory cycles for this population. This statistical determination, though defined as specific to the studied population, was reported by Hartman (1963) and Rogers (1964) in unrelated work. The specific method for determining the predicted incidence of anovulatory cycles was not defined by the McCarthy and Rockette.

From these comparisons, the <u>temperature averaging method</u> was found to be the most reliable method (95.1% biphasic, 72.4% correlated to cervical mucus within 2 days) for determining ovulation in clinical situations where concurrent interpretation is needed. Examples of such situations include timing insemination in women with infertility problems and avoiding intercourse in women who wish to avoid pregnancy.

The <u>smoothed curve method</u> can only be used for retrospective analysis of charts because interpretation depends on the average temperature for the entire cycle. McCarthy and Rockette report a high correlation to cervical mucus changes with this method but do not give the statistic. In addition, this method resulted in 96.7% biphasic charts with 76.6% showing the expected 11-16 days in the postovulatory



Original Curve



Smoothed Curve

1. Draw a line through the average temperature for the cycle.
2. Find the average of Day 1, Day 2, and Day 3 temperatures. Plot this value at Day 2. Continue in this manner throughout the cycle.
3. To be biphasic, the graph must cross the "average" line and have 7 points above the line before the temperature falls.

Figure 6. Smoothed curve method of BBT analysis.

phase.

The coverline method failed to show a thermal shift in one third of graphs when all temperatures were used and in one fourth of graphs when the last 6 temperatures were used. The incidence of biphasic graphs was 64.9% with only 38.8% showing the expected 11-16 days in the postovulatory phase. Cervical mucus correlation within 2 days was 69.3% which compares closely to the temperature averaging method (72.4%).

In summary, though this study had limitations of incomplete statistical reporting and lack of clarity on determination of the predicted incidence of anovulatory cycles used for comparison, an adequate case was made for the need for consistent interpretation of BBT graphs in both the clinical setting and for research purposes. Basal body temperature graphs seem to be a useful and reliable clinical tool for predicting ovulation when analyzed by the average temperature method and for demonstrating ovulation retrospectively by the smoothed curve method.

Conceptual Framework

The conceptual framework for this study is taken from the study of circadian rhythms. Because the environment has a daily variation of light and dark with a period of 24 hours, people have adapted to the 24 hour day. When individuals work a schedule that varies from the environmental night/day or work a schedule that is opposite from the world around them, their circadian rhythms are altered.

Women, in addition to having daily circadian cycles, have a monthly menstrual cycle. Because basal body temperatures are used to evaluate the regularity and normalcy of the menstrual cycle, an integration of the normal circadian variation of body temperature and the menstrual cycle is needed. This study addressed a small part of that integration by examining the effects of alteration in the normal circadian rhythms on that portion of the body temperature rhythm used clinically to evaluate the menstrual cycle, the BBT graph.

Research Questions

This study asked the following research questions.

Question I: Does the BBT graph predict ovulation in night workers?

Question II: Does the BBT graph of night shift workers differ from the standard BBT graph described in the literature?

Chapter II

Methods

Sample and Setting

The population for this study consisted of women working full time night shift (11pm-7am) on a regular basis. Because the study concerned BBT graphs as a predictor of ovulation, those women who were known or likely to be anovulatory were excluded. This group included post-menopausal women, pregnant women, women taking oral contraceptives, and women who had not established regular menstrual cycles after oral contraceptive use.

A convenience sample was chosen by requesting volunteers from the night shift nursing staff of a large hospital in a moderate size northwestern city. Because a high level of compliance was required of the subjects to insure adequate data collection, it was felt that a self-selected sample was justified. The sample included 11 members of a night shift nursing staff, including nursing assistants, Licensed Practical Nurses, and Registered Nurses. All subjects worked full time (at least 36 hours a week) during the course of the study.

Design

This study used a descriptive correlational design to examine the relationship between the variables of basal body temperature graphs of night shift workers and signs of ovulation. It was a prospective study in which the variable of BBT graphs were measured over 1 menstrual cycle of night shift workers. The data was then compared to the signs of ovulation and normal basal body temperature rhythms of day shift workers.

Though this design has the disadvantage of lacking experimental control which increases the risk of erroneous interpretation of the results, descriptive correlational studies are useful for their realism and generalizability (Polit and Hungler, 1983). Many studies of circadian rhythms follow a strict experimental design where individuals are subjected to schedule changes defined by the researcher. These studies frequently have a short duration whereas typical night workers are subjected to altered schedules for long periods. The rationale for the choice of a descriptive correlational design was to allow for data collection with a sample in their "natural habitat" of night shift work.

Variables

Full time night shift work

One variable in this study was full time night shift work. Full time night shift work was defined as working at least 36 hours per week from 2300 hours to 0745 hours during the course of the study. In the setting chosen, night shift schedules vary from 4 nights on and 3 nights off to 6 nights on and 3 nights off. Most schedules allow 3 consecutive nights off. Though less controlled than studies where subjects experience rigid shifts in daily schedules for defined periods, the potential for generalizability is greater because the data reflect the lifestyle of full time night shift workers who work this type of schedule.

BBT graphs

Another variable in this study was BBT graphs, the record of temperatures taken upon awakening (after at least 4 hours sleep) over one complete menstrual cycle. This was measured by subjects taking oral temperatures with single use sterile thermometers (Tempa-Dot ready strip) and plotting them on a monthly chart (Appendix D).

Single use thermometers consist of 45-50 chemical units each of which changes color at a specific temperature. Accuracy studies using specially calibrated "referee" thermometers report 94.4% accuracy as compared to 92.1% accuracy for glass mercury thermometers (Beck & St. Cyr, 1974). Kirkpatrick and Stanley (1976) report correlations of 91.2% (+/- 0.4 F) and 72.0% (+/- 0.2 F) respectively when single use sterile thermometers were compared to specially calibrated "referee" glass thermometers. This trial consisted of 125 single use thermometer readings for 30 seconds and 3 minute readings with the glass thermometer. Though this accuracy seems low, the consistent improvement over the accuracy of glass thermometers was demonstrated.

Signs of ovulation

The final variable was the occurrence of ovulation. Ovulation was measured by the subjective signs of ovulation, mittelschmirtz and subject reported vaginal mucus changes, and an objective evaluation of midcycle mucus. Mittelschmirtz, the sensation of lower abdominal pain with ovulation, was recorded on the BBT graph by the subjects. Changes in vaginal discharge were also recorded by the subjects.

Cervical mucus at the time of ovulation is thin and watery consisting of 95-98.5% water, 1% or less proteins, 0.8% NaCl, 0.5-1.5% mucin, and few cells. A qualitative crystallization test where mucus was uniformly spread on a glass slide, allowed to dry, and examined under a microscope was used to identify ovulation type mucus.

Ovulation type mucus forms "palm leaf crystals" or "ferns" and is easily identified under the microscope (Odeblad, 1973). Slides were made by the subjects and evaluated microscopically by the researcher.

Other Data

In addition to the temperature recordings, certain demographic and menstrual data was collected to facilitate data analysis through the measurement of additional variables that may have had an impact on the results. These additional variables included age, years of continuous night shift work, menstrual regularity, history of endocrine system disorders, and usual sleep patterns of both work days and days off (Appendix F). All of these parameters have been demonstrated to affect either adaptation to night work or menstrual regularity. Subjects were also asked to report any illness during the data collection period as it may have affected temperature measurements.

Procedure

The following procedure was used:

1. A request for volunteers from the full time night shift was placed in the hospital nurses newsletter (Appendix A). This notice was followed by visits to all the nursing units on two separate nights to explain the purpose of the study and solicit volunteers. The goal was 30 volunteers.

2. All volunteers were sent a cover letter (Appendix B) and a consent to participate form (Appendix C).

3. Upon receipt of the consent to participate form, the researcher met with each subject and provided written instructions

(Appendix E), a BBT chart (Appendix D), 40 single use sterile thermometers, 3 microscope slides and envelopes, and a demographic data form (Appendix F).

4. Subjects began temperature measurement on the first day of their next menstrual period, taking their temperature upon awakening (before arising, eating, drinking, or smoking). Measurement continued daily until the onset of the subject's next menses.

5. In addition to recording this temperature, the chart had a place for the subject to record the time of day the temperature was taken, the number of hours slept before awakening, the quality of the sleep, any illness during the data collection period, and any medications taken.

6. Subjects were asked to make a slide of vaginal mucus when signs of ovulation were present, i.e. a rise in temperature, an increase in mucus, or the presence of Spinn-Barkheit (stretchy) mucus, whichever came first. If no signs occurred by day 16 of the cycle subjects were asked to prepare the slide then and every other day until the onset of menses either to document the presence or the absence of ovulation. Slides, envelopes, and instructions were provided to all subjects (Appendix E).

7. The researcher contacted the subjects weekly, in person or by phone, to offer encouragement and answer questions. Additional microscope slides were provided at this time, when needed.

8. At the end of the data collection period, BBT charts were collected and analyzed by the smoothed curve technique as described on pages 19-21 (McCarthy & Rockette, 1984) to determine if they were

monophasic or biphasic. Reports of mittelschmirtz and vaginal mucus slides were used to varify ovulatory cycles.

Data Analysis

The data analysis consisted of two parts, analysis of the BBT graphs for biphasic characteristics and analysis of the reliability of BBT graphs as a predictor of ovulation in night workers. These two parts addressed research question 1 and 2.

Analysis for question 1

Question 1 addressed the question of whether the BBT graphs of night shift workers predict ovulation. The completed BBT graphs were analyzed by the smoothed curve technique previously described (McCarthy & Rockette, 1983). The resulting statistic was a percentage of monophasic and a percentage of biphasic graphs. The vaginal mucus slides were inspected microscopically for ferning and correlated by Fischer's Exact Test analysis to the respective chart revealing the statistics of biphasic charts with mucus documentation of ovulation, biphasic charts without mucus documentation of ovulation, monophasic charts with mucus documentation of ovulation and monophasic charts without mucus documentation of ovulation. Fischer's Exact Test was chosen for its appropriateness with a small sample size.

Analysis for question 2

The second question addressed if the BBT graphs of night workers differ from the typical biphasic curve existant in the literature. Rather than a statistical analysis, this was a descriptive analysis aimed at identifying patterns of variance useful in clinical practice.

Chapter III

Results and Discussion

In this chapter the findings of the study will be discussed. A description of the sample will be followed by an analysis and discussion of each research question.

Sample Description

Eleven women night workers agreed to participate in the study. Three of these original eleven did not complete their graphs (one due to a high fever, one because she did not complete one menstrual cycle during the data collection period and one because she forgot) so the final sample consisted of eight women night workers. Their ages ranged from 21 to 39 years (M=30.5; SD=7.03) and their consecutive months of full time night work ranged from 4-55 (M=21.87; SD= 18.52).

As seen in Table 1, the number of hours usually slept in the daytime (when working) and the number of hours usually slept at night (when not working) were similar with 5 subjects (62.5%) sleeping six or more hours in the day and 7 subjects (87.5%) sleeping six or more hours at night. The majority of the sample (7 subjects, 87.5%) usually slept in the morning with 3 subjects (37.5%) sleeping immediately after work and 4 subjects (50.0%) sleeping in the morning but not immediately after work. Perhaps this difference can be explained by those women with children needing to attend to responsibilities at home before going to bed whereas those women without children had no such responsibilities. The sample was evenly distributed on regularity of sleep (Table 1).

Table 1

Sleep patterns reported by night workers

	N	%
USUAL NUMBER OF HOURS SLEPT - DAY		
4-6 HOURS	3	37.5
6-8 HOURS	4	50.0
> 8 HOURS	1	12.5
USUAL NUMBER OF HOURS SLEPT - NIGHT		
4-6 HOURS	1	12.5
6-8 HOURS	5	62.5
> 8 HOURS	2	25.0
USUAL TIME OF DAY SLEPT		
Morning, immediatly after work	3	37.5
Morning	4	50.0
Afternoon	0	00.0
Evening, just prior to work	0	00.0
Split times	1	12.5
REGULARITY OF SLEEP		
Same time every day	1	12.5
Mostly same every day	2	25.0
Sometimes different	2	25.0
Different every day	3	37.5

Each subject was asked baseline information about her menstrual history and this data is summarized in Table 2. The range for age of menarche was 11-12 years (x=11.5). Fifty percent had cycles lasting between 25 - 28 days and 75% had cycles lasting between 25 - 35 days. Two individuals had cycles lasting from 36 - 39 days. All subjects reported regular cycles. The average duration of menses in this sample ranged from 2 - 7 days with 25 % reporting 2 - 4 days and 75.0% reporting 5 - 7 days. This data confirms the use of a "normal" sample as all of this menstrual history data falls within the norms for a population in this age range (Hartman, 1972; Collett, Wertenberger and Fisk, 1954).

Research Questions

Findings relevant to the two research questions will be analyzed. Because of the small sample and descriptive nature of the analysis, a discussion of the findings will be included in this section.

Question One

Research question one asked if the basal body temperature graphs of night workers predicted ovulation. The characteristic of the BBT graph (monophasic or biphasic) was compared to the presence or absence of ovulation (fern or no fern) with the Fischer's Exact Test (Table 4). No significant result was found.

The evaluation of the graphs using the smoothed curve technique described by McCarthy and Rockette (1983) revealed four biphasic graphs and four monophasic graphs. Microscopic review of the slides showed two with a positive fern test and six with a negative fern test. Of the four biphasic (ovulatory) charts, one had a positive fern test so that ovulation was correctly predicted only 25% of the

Table 2

Subject's self reported menstrual information

	N	%
AGE OF MENARCHE		
Range: 11-12 years x = 11.5 SD = .53		
REGULARITY OF CYCLE		
Regular	7	87.5
Not regular	0	00.0
N/R	1	12.5
LENGTH OF CYCLE		
25-28 days	4	50.0
29-31 days	1	12.5
32-35 days	1	12.5
36-39 days	2	25.0
AVERAGE DURATION OF MENSES		
2-4 days	2	25.0
5-7 days	6	75.0

time. Of the four monophasic (anovulatory) charts three did not fern, correctly depicting an anovulatory cycle 75% of the time. In summary, 50% of the graphs either correctly predicted ovulation or correctly marked an anovulatory cycle.

Table 3 is a summary of the comparison between ovulatory signs and the BBT graph characteristics for each subject. Of the two subjects with a positive fern test, one reported mittelschmirtz and one reported mucus changes. Only two subjects denied any signs of ovulation; one had a monophasic graph and one had a biphasic graph with a 22 day luteal phase (not typical for an ovulatory cycle). Two more subjects reported experiencing mittelschmirtz and both had biphasic graphs. The remaining two subjects reported mucus changes and both had monophasic graphs. In summary, there was poor correlation between self reported signs of ovulation (mittelschmirtz and mucus changes) and mucus ferning. Perhaps the method for making vaginal mucus slides led to subject error.

In the normal population, aged 21-39, the reported incidence of ovulation is 92.1% (Hartman, 1972). Even if this sample had confirmed this incidence of ovulation such that 7 out of 8 subjects had ovulated, the results of the Fischer's Exact Test would not have been significant ($p = 0.125$). This indicates that this sample size could not have picked up a significant difference regardless of the outcome. The results of the Fischer's Exact Test (Table 4) using the obtained values reveal a p of 0.517. Because the value is greater than $p = 0.05$, the test results are not significant.

In this case, the lack of statistical significance may be

Table 3

Comparison of ovulatory signs and BBT graph characteristics

		Ovulatory signs			
		Subjective		Objective	
BBT GRAPH	SUBJECT #	MITTLESCHMIRTZ	MUCUS	FERN	COMMENTS ON BBT GRAPHS
Biphasic	1	+	-	-	Extremely variable
Biphasic	4	+	-	+	Extremely variable
Biphasic	6	+	-	-	Elevated follicular phase
Biphasic	7	-	-	-	22 day luteal phase
Monophasic	2	-	-	-	Flat BBT
Monophasic	3	-	+	-	Extremely variable
Monophasic	5	-	+	+	Extremely variable
Monophasic	8	-	+	-	Extremely variable

Table 4

Fischer's Exact Test using obtained results

	Fern	No Fern	
Monophasic	1	3	4
Biphasic	1	3	4
	2	6	8

Fischer's Exact Test: $$\frac{(a = b)!\ (c + d)!\ (a + c)!\ (b + d)!}{N!\ a!\ b!\ c!\ d!} =$$

$$\frac{(1 + 3)!\ (1 + 3)!\ (1 + 1)!\ (3 + 3)!}{8!\ 1!\ 3!\ 1!\ 3!} =$$

$p = 0.571$

attributable to several factors. The primary reason, however, is the small sample size. It is interesting to note however, had the sample size been doubled with the same distribution found in this study, the value for p would have been 0.001 (using Fischer's Exact Test).

Question two

Research question two, asked if the BBT graphs of night workers differed from the standard BBT graph found in the literature. In this study, significant differences from "typical" BBT graphs were noted. Basically, though the curves divided into two groups, biphasic and monophasic, the configuration of the graphs varied markedly from the standard found in the literature. All BBT graphs, both original and smoothed curves, are found in Appendix G by subject number.

The biphasic graphs (subjects 1, 4, 6, 7) , when smoothed, all had a similar shape with a follicular phase rise (though not above the average temperature line), a midcycle nadir and a sustained luteal phase rise. Unlike the "typical" BBT graph found in the literature that has no follicular phase temperature rise, a consistent follicular phase rise was noted in this study. One graph (subject 7) showed a 22 day luteal phase which, though biphasic, does not reflect a "typical" ovulatory phase. The original curves (before "smoothing") show marked daily variability of 0.2 to 1.0 F change each day.

From the literature review, one would expect lower temperatures in the morning and higher temperatures in the afternoon. In some cases, similar temperatures were recorded on consecutive days when the time of awakening varied from 4-8 hours. Therefore the marked variation in temperatures cannot be explained by the differences in time of day (and hence the point on the circadian temperature rhythm) the temperatures were taken. The reason for this marked variation remains to be explained.

The monophasic graphs were of 2 types, extremely flat or extremely variable. The flattened curve (subject 2) showed little daily variation with no significant sustained rise at any time in the cycle. There was, however, a slight rise midcycle (days 14, 16, 17) which prospectively would most likely be interpretted as ovulation by the woman using the BBT graph to predict ovulation. This subject, however, had neither subjective nor objective signs of ovulation. The extremely variable monophasic graphs (subjects 3, 5, 8) showed a follicular phase rise, a midcycle fall, and a luteal phase rise in the smoothed curve. Again, like the biphasic graphs, prospectively these graphs would be difficult to evaluate due to the extreme daily variation of 0.2-1.0 F. For the individual attempting to use the BBT graph to predict ovulation, this variation would be extremely confusing and potentially frustrating.

Though all temperatures were taken upon awakening, the lifestyle of night workers leads to great variation in the time of day temperatures were taken. Interestingly, the majority of temperatures taken in the morning were high and the majority of temperatures taken in the afternoon or evening were low suggesting a reversal of the normal circadian temperature variation.

In summary, the BBT graphs of night shift workers seem to differ significantly from those of day workers. That fact, combined with the low incidence (25%) of objective signs of ovulation raises two questions. Does night shift work obscure documentation of ovulation with BBT graphs because of circadian temperature changes, or does night shift work infact have a direct impact upon ovulation?

Additional findings

In addition to the completed demographic forms and BBT graphs, many subjects expressed interest in understanding their menstrual cycles better and particularly the impact of night work on the menstrual cycle. Many discussions on the effects of night shift work on their physiologic systems were prompted by the study. Night workers seemed interested and desired to learn about the impact of night work on their bodies.

Chapter IV

Summary and Recommendations

In this chapter a summary of the study will be followed by a discussion of the limitations of the study. Implications for nursing practice and suggestions for further research will then be presented.

Summary

There are several physiologic rhythms (called circadian rhythms) in the individual which last approximately 24 hours. One of the rhythms is the temperature rhythm, a sine wave with a nadir at approximately 0400 hours and a zenith between 1500 and 2100 hours. Women, during their years of fertility, also have a menstrual cycle rhythm which has an impact upon their circadian temperature rhythm when hormonal levels cause changes in body temperature. This rise is noted in the basal body temperature (BBT) graph.

BBT graphs are used clinically to predict ovulation both for women desiring conception and as a means of contraception. The "basal" conditions are defined as temperature taken upon awakening, after at least 4 hours of sleep, before eating, smoking or arising. In women who sleep at approximately the same time every day, this "basal" temperature is taken at nearly the same point on the individual's circadian temperature rhythm. These BBT graphs form a characteristic pattern in ovulatory women. Because night workers sleep during the daytime when they work and at night when they are not working, the time when they awaken falls at variable points on their circadian temperature rhythm. Consequently the validity of the BBT graph as a predictor of ovulation in the population of night workers is questionable. Two research questions were developed: (1) Does the BBT graph predict ovulation in night workers? and, (2) Does the BBT graph of night workers differ from the standard BBT graph described in the literature.

Eight women night workers aged 21-39 who had worked full time night shift for 4-55 months participated in the study. They completed a short demographic form on sleeping patterns and menstrual history, completed a BBT graph for one complete menstrual cycle, and provided a microscope slide(s) of vaginal mucus at midcycle. The BBT graphs were analyzed by the smoothed curve technique of McCarthy and Rockette (1983) and labeled either monophasic or biphasic. Ovulatory slides were evaluated microscopically for ferning (positive sign of ovulation). The results of the Fischer's Exact Test comparing BBT graph characteristics (monophasic and biphasic) to ovulatory signs (ferning) were not statistically significant.

Four of the BBT graphs were biphasic indicating a cycle that should have been ovulatory. However, clinical signs of ovulation were present in only one. Four of the BBT graphs were monophasic, indicating a cycle that should have been anovulatory. In fact, 3 of these 4 were clinically anovulatory. Therefore a biphasic chart correctly predicted ovulation only 25% of the time. A monophasic chart, on the other hand, correctly predicted anovulation in 75% of cases.

It should be noted, however, that although these charts could be classified as biphasic or monophasic, they differed markedly from typical biphasic and monophasic charts of day workers. The graphs show significant variability in daily temperatures ranging from 0.2 to 1.0 F. Due to this marked variability, prospective use of these graphs to predict ovulation would be confusing.

Limitations

There are several limitations that may have influenced the results of this study. The most obvious is the problem of small sample size. A lack of significant findings may be related to such a small number of participants. Because most of the subjects worked together throughout the data collection period, stresses in the workplace may have had an impact upon the menstrual cycle normalcy of the sample. Additionally, the use of BBT graphs from a single menstrual cycle of each subject further limits the generalizability of the results to other groups of night workers.

Because the incidence of ovulation was far below the expected 92.1% (Collett et al., 1954), the method for evaluating ovulation becomes suspect. Incorrect technique by the subjects may have masked the signs of ovulation. In addition, other factors such as vaginal infections and the use of spermicides and douches were not controlled for and consequently may have obscured ovulatory mucus. Perhaps the presence of Spinn-Barkheit mucus or cervical smears done by the investigator midcycle would have more accurately measured the incidence of ovulatory cycles for this study. Also, it is unclear whether night shift work itself has an impact on ovulation. Demographic data on fertility, infertility and delayed fertility in the sample would have helped determine if the sample was abnormal in respect to ovulation.

Basal body temperatures are usually taken with a BBT thermometer which registers temperature variation of as little as 0.1 F. The use of rapidly registering single use thermometers was chosen to increase subject compliance and decrease cost to the researcher. The single use thermometers register to the 0.2 F, perhaps accounting somewhat for the marked variability in the sample's BBT graphs. Perhaps too this limitation was offset by the increased accuracy of the single use thermometers as demonstrated by Beck and St. Cyr (1974) and Kirkpatrick and Stanley (1976). Even so, the use of thermometers other than the standard BBT thermometer is a limitation of this study. The use of a dayshift control group would have provided valuable information on the thermometers.

Implications for nursing

Nurses who work with women must understand the impact of varied lifestyles on the menstrual cycle, fertility, and conception. This study addressed the impact of night shift work on the most widely used clinical tool for predicting ovulation and evaluating menstrual cycle normalcy, the BBT graph. In suggesting the use of BBT graphs to women desiring more information on their menstrual cycle, or particularly to women desiring to predict ovulation, nurses must evaluate lifestyle for regularity of sleep. Women who work at night and sleep at variable times should be cautioned about the potential difficulty of prospective interpretation of graphs.

In addition the nursing profession must begin to recognize the impact of night work on the individual. Nursing research should focus on the psychological and physiological impacts of night work. It may prove helpful for nursing administrators to incorporate research data on circadian rhythms into scheduling of night workers to minimize their difficulties.

Suggestions for Further Research

Several suggestions for further research emerge from this study. First, a replication of this study with a larger sample size over several menstrual cycles is needed. Methodological problems, such as the use of BBT thermometers and the procedure for making vaginal mucus slides should be addressed.

Second, a prospective study of women before starting night work and through the transition to night work, would provide needed data on adaptation to night work. Circadian temperature rhythms are an inexpensive and easily accessible means of assessing adaptation to altered schedules.

Third, because the incidence of ovulation in the sample was low, a study of the incidence of ovulation in night workers would be helpful to determine if night work has an impact on regularity of ovulation. Ways of gathering this information include descriptive data on fertility, cycle regularity, dysmenorrhea, and the subjective signs of ovulation. Objective data would include hormonal assays, BBT graphs and cervical mucus slides for midcycle ferning.

Finally, the lack of correlation between commonly used subjective signs of ovulation and the objective evidence of ovulation leads to questions about the validity of these signs for "fertility awareness". Further study of these signs (mucus changes and mittelschmirtz) is needed to document accuracy in the normal population.

References

Akerstedt, T. (1977). Inversion of the sleep wakefulness pattern: Effects on circadian variations in psychophysiological activation. *Ergonomics*, *20*, 459-74.

Akerstedt, T., & Gillberg, M. (1980). Sleep disturbances and shift work. In A. Reinberg, N. Vieux, & P. Andlauer (Eds.), *Night and shift work: Biological and social aspects*. New York: Pergammon.

Akerstedt, T., Torsvall, L., Gillberg, M. (1982). Sleepiness and shift work: Field studies. *Sleep*, *5*, S95-S105.

Aschoff, J. (Ed.).(1965). *Circadian clocks: Proceedings of the Feldafing Summer School*. Amsterdam: North-Holland Publishing Co.

Aschoff, J. (1978). Features of circadian rhythms relevant for the design of shift schedules. *Ergonomics*, *21*, 739- 754.

Aschoff, J., Daan, S. & Groos, G. (Eds.). (1982). *Vertebrate Circadian Systems*. Heidelberg: Springer-Verlag.

Aschoff, J., Fatranska, M, Gerecke, Y. (1974). Twenty-four hour rhythms of rectal temperature in humans: Effects of sleep interruptions and of test sessions. *Pflugers Archives*, *346*, 215-222.

Aschoff, J., Hoffman, K., Pohl, H., & Wever, R. (1975). Reentrainment of circadian rhythms after phase-shifts of the zeitgeber. *Chronobiologia*, *2*, 23-78.

Bauman, J. E. (1981). Basal body temperature: Unreliable method of ovulation detection. *Fertility and Sterility*, *36*, 729-733.

Beck, W. C., & St. Cyr, B. (1974). Oral thermometry. *The Guthrie Bulletin*, *43*, 170-185.

Brady, J. (Ed.).(1982). Biological time keeping. Cambridge: Cambridge University Press.

Bunning, E. (1973). The physiological clock: Circadian rhythms and biological chronometry. London: English University Press.

Burry, K. (1984, October). Oral contraceptives. Lecture presented at Oregon Health Sciences University, Portland OR.

Cebanac, M., Hildebrandt, G., Massonet, B. (1976). A study of the nychthemeral cycle of behavioural temperature regulation in man. Journal of Physiology, 257, 275-291.

Collett, M. E., Werternberger, G. E., Fiske, V. M. (1954). The effect of age upon the menstrual cycle. Fertility and Sterility, 5(5), 437-440.

Colquhoun, W., Blake, M., & Edwards, R. (1968). Experimental studies of shift-work II: Stabilized 8-hour shift systems. Ergonomics, 11, 527-546.

Colquhoun, W. P., Folkard, S., Knauth, P., & Rutenfranz, J. (Eds.). (1975). Experimental studies of shift work. Opladen: Westdeutscher Verlag.

Conroy, R., Elliott, A., & Mills, J. (1970). Circadian excretory rhythms in night workers. British Journal of Industrial Medicine, 27, 356-363.

Conroy, R. T. W. L., & Mills, J. N. (1970). Human circadian rhythms. London: J.A. Churchill.

Czeisler, C. A. (1982). Rotating shift work schedules that disrupt sleep are improved by applying circadian principles. Science, 217, 460-463.

D'Amour, F. E. (1943). A comparison of methods used in determining the time of ovulation. Journal of Clinical Endocrinology, 3, 41-48.

Denney, D., Kinzie, D., Sack, R., & Lewy, A. (1982). Measurement of motor activity and body temperature in psychiatric patients. Unpublished manuscript.

Elliott, A. L., Mills, J. N., Minors D. S. (1972). The effect of real and simulated time zone shifts upon circadian rhythms of body temperature, plasma 11-hydrocorticosteroids, and renal excretion in human subjects. Journal of Physiology, 221, 227-257.

Elstein, M., Moghissi, K., & Borth, R. (Eds.). (1973). Cervical mucus in human reproduction. Copenhagen: Scriptor.

Felton, G. (1970). Effect of time cycle change on blood pressure and temperature in young women. Nursing Research, 19, 48-58.

Felton, G. (1975). Body rhythm effects in rotating work shifts. Journal of Nursing Administration, 10, 16-19.

Felton, G., & Ward, J. (1977). Regression models in the study of circadian rhythms in nursing research. International Journal of Nursing Studies, 14, 151-161.

Folkard, S., Monk, T., & Lobban, M. (1978). Short and long term adjustment of circadian rhythms in "permanent" night nurses. Ergonomics, 21, 785-799.

Folkard, S., & Monk, T. H. (1980). Individual differences in the circadian response to a weekly rotating shift system. In A. Reinberg, N. Vieux, & P. Andlauer (Eds.), Night and shift work: Biological and social aspects (pp. 367- 374). New York: Pergammon Press.

Gadbois, C. (1980). Women on night shift: Interdependence of sleep and off-the-job activities. In A. Reinberg, N. Vieux, & P. Andlauer (Eds.), Night and shift work: Biological and social aspects (pp. 223-227). New York: Pergammon Press.

Garcia, J., Seegar Jones, G., & Wright, G. (1981). Prediction of the time of ovulation. Fertility and Sterility, 36, 308-315.

Hartman, C. G. (1972). Science and the safe period: A compendium of human reproduction. New York: Robert E. Krieger Publishing Company.

Haughty, G. T., & Adams, T. (1965). Phase shifting of the human circadian system. In J. Aschoff (Ed.), Circadian clocks: Proceedings of the Feldafing Summer School (pp. 413-425). Amsterdam: North-Holland Publishing Co.

Harvey, O. L., & Crocket H. E. (1932). Individual differences in temperature changes of women during the course of the menstrual cycle. Human Biology, 4, 453-468.

Henane, R., Buguet, A., Roussel, B., & Bittel, J. (1977). Variations in evaporation and body temperatures during sleep in man. Journal of Applied Physiology: Respiratory, Environmental, and Exercise Physiology, 42, 50-55.

Hilgers, T. W., & Bailey A. J. (1980). Natural family planning. II. Basal body temperature and estimated time of ovulation. Obstetrics and Gynecology, 55(3), 333-339.

Ilmarinen, J., Ilmarinen, R., Korhonen, O., & Nurminen, M. (1980). Circadian variation of physiological functions and their relationship to oral temperature. In A. A. Reinberg, N. Vieux, P. Andlauer (eds.). (1980). Night and shift work: Biological and social aspects (pp. 91-98). New York: Pergammon Press.

Kirkpatrick, M., & Stanley, S.M. (1976). Evaluation of a new single-use thermometer. Occupational Health Nursing, 24(12), 9-18.

Knauth, P., and Ilmarinen, K. (1975). Continuous measurement of body temperature during a three week experiment with inverted working and sleeping hours. In P. Colquhoun, S. Folkard, P. Knauth, J. Rutenfranz, (Eds.). (1975). Experimental Studies of Shift Work (pp. 66-73). Opladen: Westdeutcher Verlag.

Knauth, P. and Rutenfranz, J. (1976). Experimental shift work studies of permanent night and rapidly rotating shift systems. International Archives of Occupational and Environmental Health, 37, 125-137.

Leonard, R. (1980). Night and shift work. In A. Reinberg, N. Vieux, & P. Andlauer (Eds), Night and shift work: Biological and social aspects (pp. 323-329). New York: Pergammon Press.

Lundy, L. E., Lee, S. G., Levy, W., Woodruff, J. D., Wu, C., & Abdalla, M. (1974). The ovulatory cycle: A histologic, thermal, steroid, and gonadotropin correlation. Obstetrics and Gynecology, 44, 14-25.

Martin, P. (1943). Detection of ovulation by the basal temperature curve with correlating endometrial studies. American Journal of Obstetrics and Gynecology, 46, 53-62.

McCarthy, J. J., and Rockette, H. (1983). A comparison of methods to interpret the basal body temperature graph. Fertility and Sterility, 39, 640-646.

Mills, J. N. (1966). Human circadian rhythms. Physiology Review, 46, 128-171.

Mills, J. N. (1968). Temperature and potassium excretion in a class experiment in circadian rhythmicity. Journal of Physiology, 194, 19P.

Mills, J., Minors, D., & Waterhouse, J. (1978). Exogenous and endogenous influences on rhythms with a sudden time shift. Ergonomics, 21, 755-761.

Mills, J., Minors, D., & Waterhouse, J. (1978). The effect of sleep upon human circadian rhythms. Chronobiologia, 5, 14-27.

Minors, D., Mills, J., & Waterhouse, J. (1976). The circadian variations of the rates of excretion of urinary electrolytes and of deep body temperature. International Journal of Chrenology, 4, 1-28.

Minors, D. S., Waterhouse, J. M. (1981). Circadian Rhythms and the Human. Boston: Wright PSG.

Moghissi, K. (1976). Accuracy of basal body temperature for ovulation detection. Fertility and Sterility, 27, 1415-1421.

Moghissi, K. S., Syner, F. N., Evans, T. N. (1972). A composite picture of the menstrual cycle. American Journal of Obstetrics and Gynecology, 114, 405-418.

Moore-Ede, C., Czeisler, C. A., Richardson, G. S. (1983). Circadian timekeeping in health and disease. Part two: clinical implications of circadian rhythmicity. New England Journal of Medicine, 309, 530-536.

Naisbitt, J.N. (1982). Megatrends. New York: Warner.

Odeblad, E. (1973). Biophysical techniques of assessing cervical mucus and microstructure of cervical endothelium. In M. Elstein, K. Moghissi, & R. Borth (Eds.), Cervical mucus in human reproduction (pp. 58-74). Copenhagen: Scriptor.

Pauerstein, C., Eddy, C., Croxatto, H. D., Hess, R., Siler-Khodr, T., Croxatto, H. B. (1978). Temporal relationships of estrogen, progesterone, and lutenizing hormone levels to ovulation in women and infrahuman primates. American Journal of Obstetrics and Gynecology, 130, 876-886.

Polit, D. and Hungler, B. (1983). Nursing research: Principles and methods (2nd ed.). Philadelphia: Lippincott.

Reinberg, A., Vieux, N., Ghata, J., Chaumont, A., & Laporte, A. (1978). Circadian rhythm amplitude and individual ability to adjust to shift work. Ergonomics, 21, 763-66.

Reinberg, A., Vieux, N., Andlauer, P. (eds). (1980). Night shift work Biological and social aspects. New York: Pergammon Press.

Romanczyk, R., Crimmins, D. L., Gordon, W., & Kashinsky, W. (1977). Measuring circadian cycles. A simple temperature recording preparation. Behavior Research Methods and Instrumentation, 9, 393-394.

Rubenstein, B. B. (1940). The vaginal smear-basal body temperature technic and its application to the study of functional sterility in women. Endocrinology, 27, 843-856.

Rutenfranz, J., Colquhoun, W. P., Knauth, P., and Ghata, J. (1977). Biomedical and psychosocial aspects of shift work: A review. Scandanavian Journal of Work, Environment, and Health, 3, 165-182.

Scherren, J. (1980). Man's work and circadian rhythms through the ages. In A. Reinberg, N. Vieux, and P. Andlauer (Eds). (1980). Night and shift work: Biological and social aspects (pp. 1-9). New York: Pergammon Press.

Sollberger, A. (1965). Biological rhythm research. New York: Elsevier.

Speroff, L., Glass, R. H., Case, N. G. (1983). Clinical Gynecologic Endocrinology and Infertility (3rd ed.). Baltimore: Williams and Wilkins.

Tompkins, P. (1944). The use of basal temperature graphs in determining the date of ovulation. Journal of the American Medical Association, 124, 698-700.

VanLoon, J. H., (1963). Diurnal body temperature curves in night workers. Ergonomics, 6, 267-273.

Vokac, Z., Magnus, P., Jebens, E., & Gundersen, N. (1981). Apparent phase shifts of circadian rhythms (masking effects) during rapid shift rotation. International Archives of Occupational and Environmental Health, 49, 53-65.

Wehr, T. A., Goodwin, F. K. (eds.). (1983). Psychobiology and Psychopathology: Volume 2. Circadian rhythms in psychiatry. Pacific Grove, California: Boxwood Press.

Wever, R. (1983). Organization of the human circadian system: Internal interactions. In T. A. Wehr, F. K. Goodwin (Eds), Psychobiology and Psychopathology: Volume 2. Circadian rhythms in psychiatry. Pacific Grove, California: Boxwood Press.

Zuck, T. (1938). The relation of basal body temperature to fertility in women. American Journal of Obstetrics and Gynecology, 36, 998-1005.

Appendix A

Request for Volunteers in
Hospital Nursing Newsletter

Volunteers are requested for a study of the effects of full time night work on basal body temperature graphs. Thermometers and graphs will be distributed! If interested, please contact Nancy MacMorris-Adix at (phone number).

Appendix B

Oregon Health Sciences University
School of Nursing
Department of Family Nursing

Dear Subject:

I am a graduate student in nursing at the Oregon Health Sciences University. I am conducting a research project on the effects of night shift work on basal body temperature graphs. It is my hope that the research will help in determining if night shift workers can use basal body temperature graphs to predict ovulation.

Your signiture on the attached permission form is necessary to allow your participation in the study. I would be happy to answer questions that you may have and I may be reached at home, (phone number). Results of the study will be sent to you if you so indicate on the attached consent form.

I appreciate your willingness to be involved in this study.

Sincerely,
[redacted]
Nancy MacMorris-Adix, RN, BSN

Attachment

Appendix C

Oregon Health Sciences University
Department of Family Nursing
Portland, OR 97201

Principle investigator: Nancy MacMorris-Adix, RN, BSN
Telephone (phone number)

SUBJECT NAME:____

I,__________________________________, herewith agree to serve as
(night shift worker name)
a subject in the investigation "Circadian Effects on Basal Body Temperature Graphs in Night Shift Workers" by Nancy MacMorris-Adix under the supervision of Carol Howe CNM, DNS. The purpose of the study is to determine if night shift workers can use basal body temperature graphs to predict ovulation. The subjects will all be female, full time night shift workers. Participation in this study involves taking my temperature each day when I wake up with a single use thermometer supplied by the investigator. Temperature measurement will take 60 seconds each day. I will then have to chart my temperature on a monthly graph supplied by the investigator. In addition, I will have to make 1 or more slides of my vaginal mucus by touching my vaginal opening and smearing the resulting fluid on a slide. I will participate throughout one complete menstrual cycle. In addition, I will complete a demographic data form requiring approximately 10 minutes of my time.

I understand that I will recieve no personal benefit or remuneration from participating in this study. However, by serving as a subject, I will contribute to new knowledge that may assist health professionals in health promotion. No names will be used. I understand that anonymity and confidentiality will be provided by the use of code numbers. I understand there are no known risks of participation in this study.

I understand that I am free to withdraw from participation in the study at any time without affecting my employment at Salem Hospital.

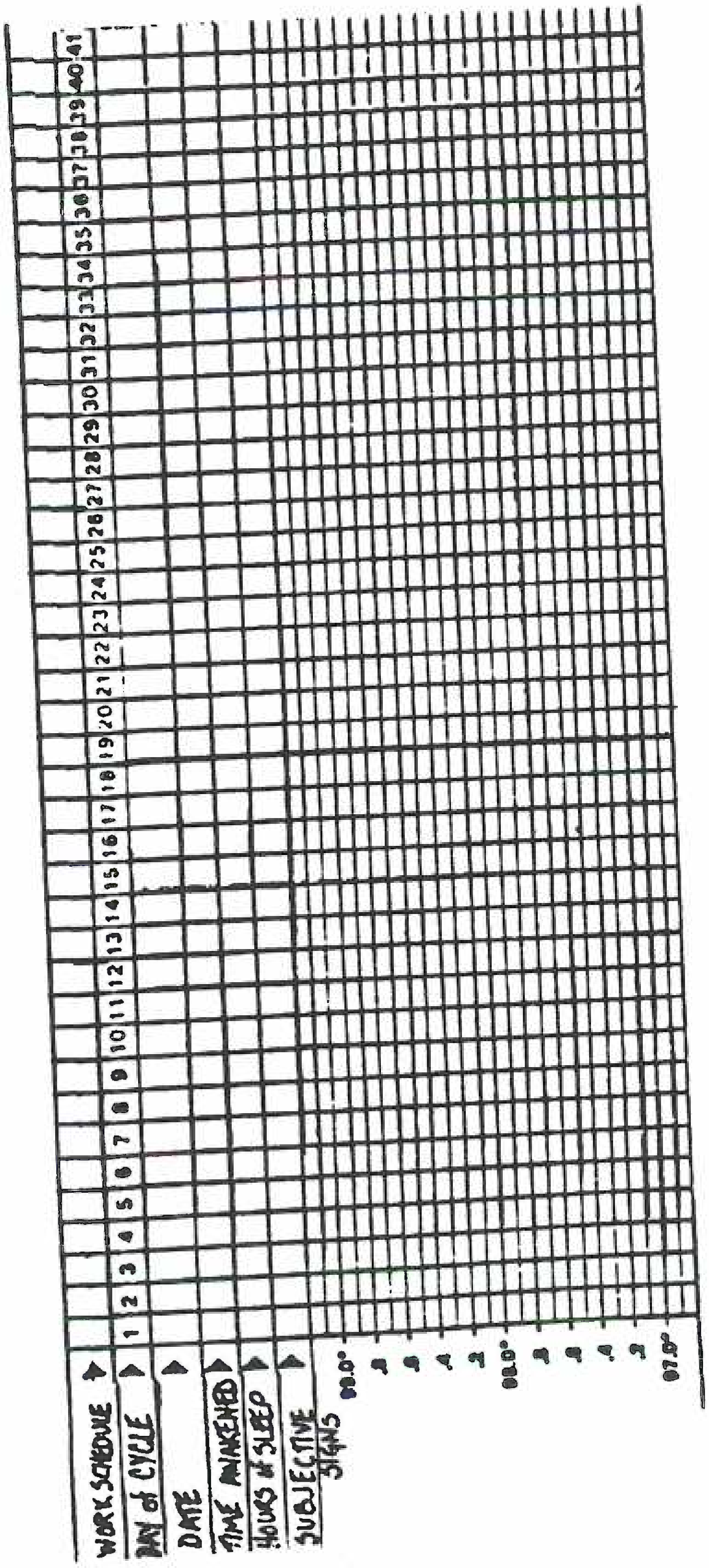
I certify that as of this date I consent to participation in this study.

____ Date____________________
Subject

I would like a copy of the study results________.

Appendix D

BASAL BODY TEMPERATURE RECORD



Appendix E

Instructions For Keeping a Temperature Record

1. Each day, upon awakening, but before you get out of bed, place a single use thermometer in your mouth for at least 60 seconds. Do this every day regardless of what time of day you awaken. Be sure not to eat, drink, or smoke before taking your temperature. Chart this value in the first empty column on the chart.

2. Insert date on line marked "Date".

3. Insert the time of day when you awaken in the square directly below 1.

4. Insert the number of hours you slept prior to awakening on the line marked "Hours of Sleep".

5. Ovulation in some women may be accompanied by a twinge of pain in the lower abdomen or a sticky vaginal mucus discharge. If you notice either of these, indicate them on the line marked "Subjective Signs".

6. Fill in a "W" for work and a "O" for off on the line marked "Work Schedule".

7. When you notice a rise in temperature, the presence of increased vaginal mucus, the presence of stretchy (Spinn-Barkeit) mucus, or when you reach day 16 of your cycle, smear some vaginal secretions on the microscope slide provided. To obtain these secretions, first wash your hands, spread your labia with one hand, touch your vaginal opening with 1 finger of the other hand, and smear the resulting secretions onto the slide. Allow the slide to dry completely and place it in the envelope provided. Put the date on the frosted end of the slide.

8. If you do not notice a rise in temperature, the presence of increased vaginal mucus, or the presence of stretchy (Spinn-Barkeit) mucus, repeat the vaginal slide technique every other day (Day 16, 18, 20, etc.) until either these signs appear or until the onset of menses. Date each slide on the frosted end.

9. At the end of 1 complete menstrual cycle, the investgator will collect the temperature chart, demographic data form and microscope slide(s).

Appendix F

For
Computer
Use
Only

Demographic Data

__ __ Identification Number________
Subject Name:____
__ __ Age:__________________

Night shift information

__ __ __ Number of consecutive months of full time night work: __________

Usual number of hours slept in daytime:
__ _____1. 0-1 hours
_____2. 2-4 hours
_____3. 4-6 hours
_____4. 6-8 hours
_____5. greater than 8 hours

Usual time of day slept:
__ _____1. immediatly after work
_____2. morning, but not immediatly after work
_____3. afternoon
_____4. evening, just prior to work
_____5. split times (such as 2 hours in AM and 2 hours in evening)

Usual number of hours slept at night:
__ _____1. 0-1 hours
_____2. 2-4 hours
_____3. 4-6 hours
_____4. 6-8 hours
_____5. greater than 8 hours

Regularity of sleep:
__ _____1. same time every day
_____2. mostly same every day
_____3. sometimes different
_____4. different every day

__ Do you take any medications on a regular basis?_____1. yes
_____2. no

If yes, please list: ______________________________________
____

Menstrual information

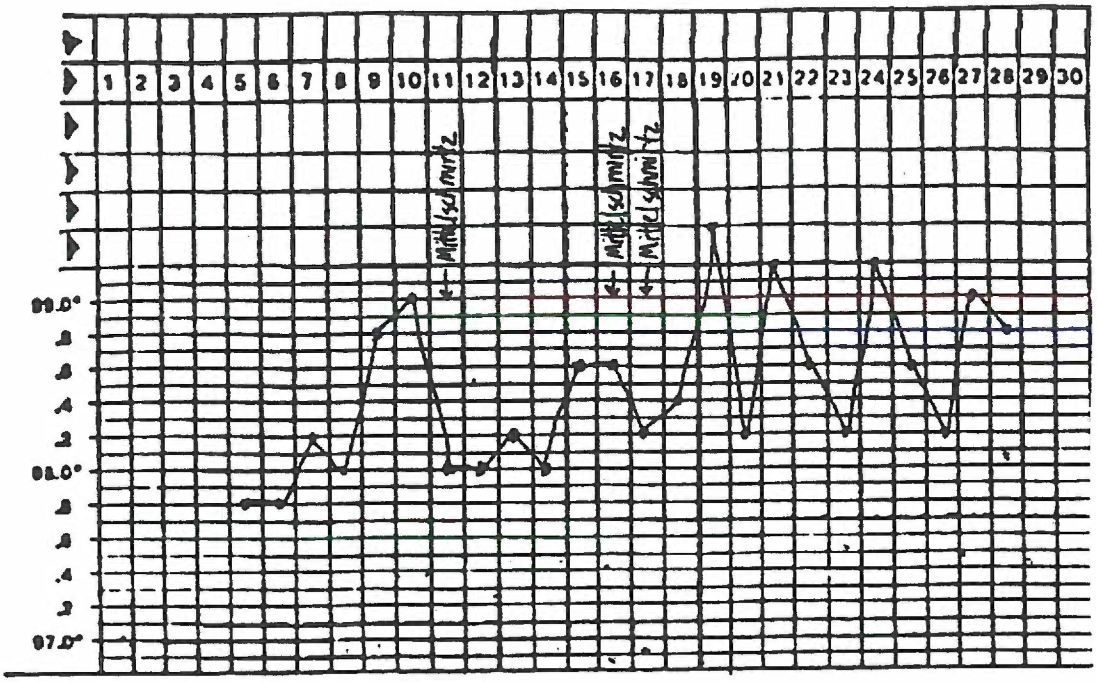
__ __ Age when started menstruating__________________

Length of cycle:
__ _____1. less than 21 days
_____2. 21-24 days
_____3. 25-28 days
_____4. 29-31 days
_____5. 32-35 days
_____6. 36-39 days
_____7. greater than 39 days

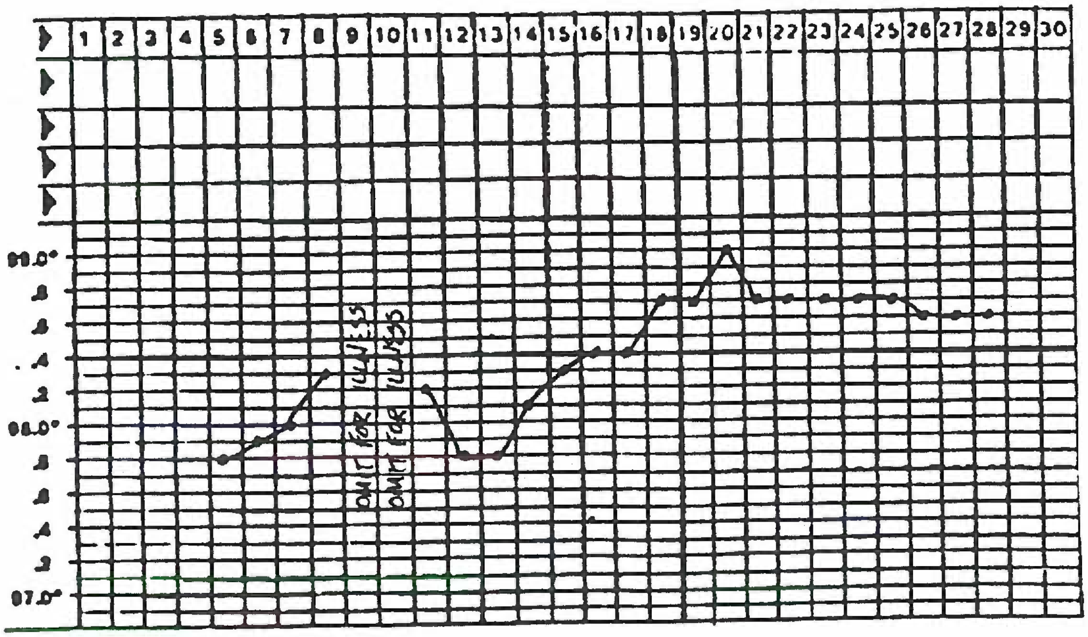
__ Are your cycles regular? _____1. yes
_____2. no

Average duration of menses (include all days of flow, including spotting)
__ _____1. less than 2 days
_____2. 2-4 days
_____3. 5-7 days
_____4. more than 7 days

Appendix G



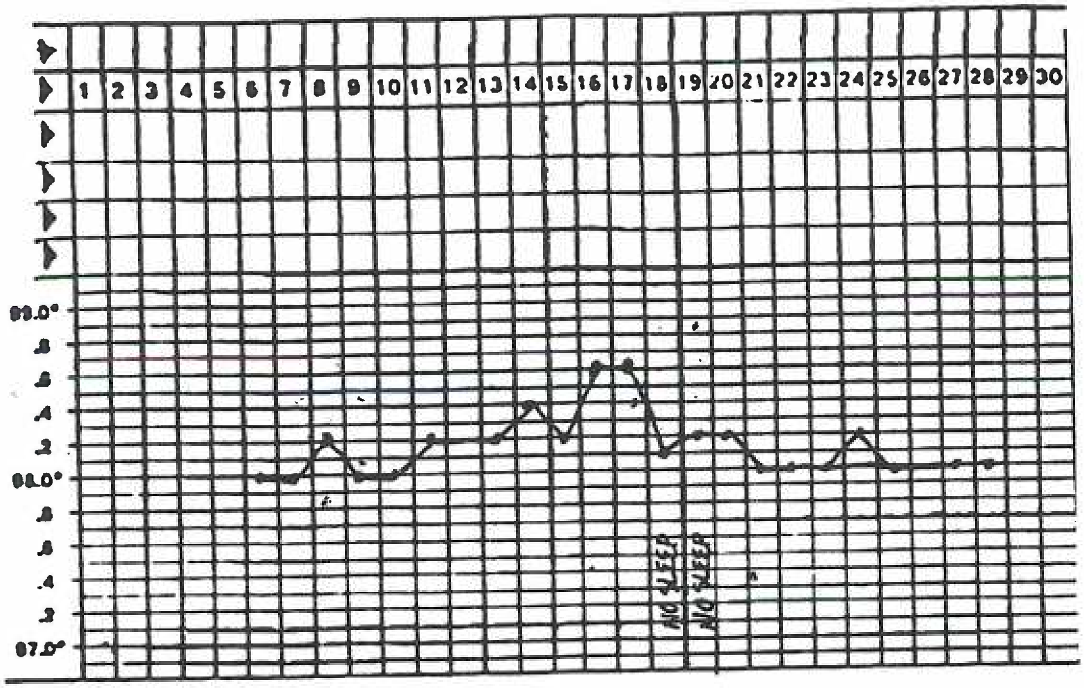
Original Curve



Smoothed Curve

average temperature = 98.4 F

Subject 1



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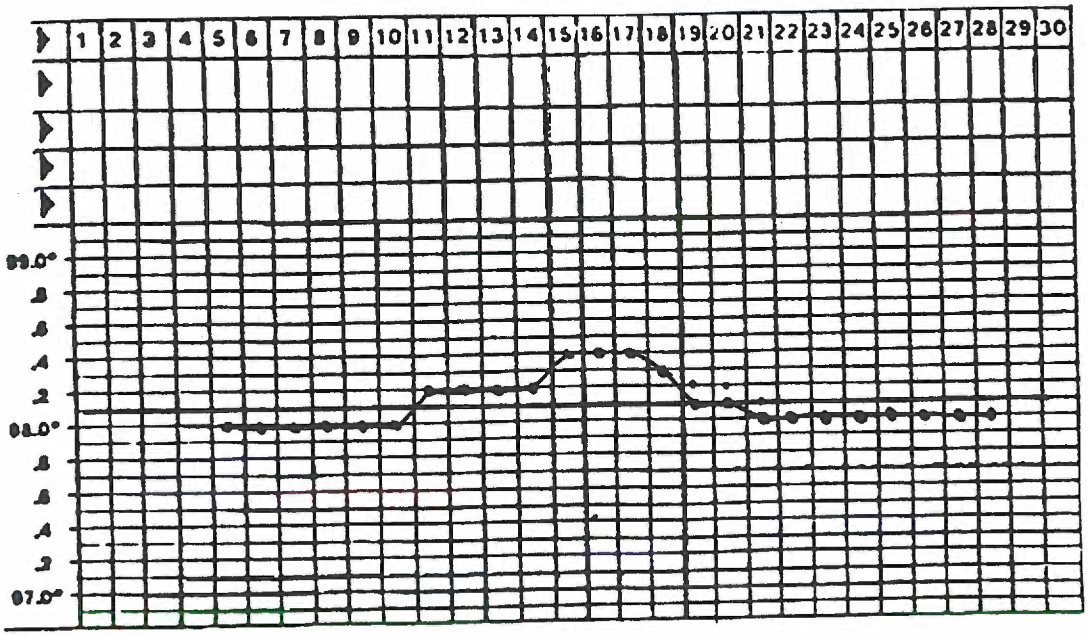
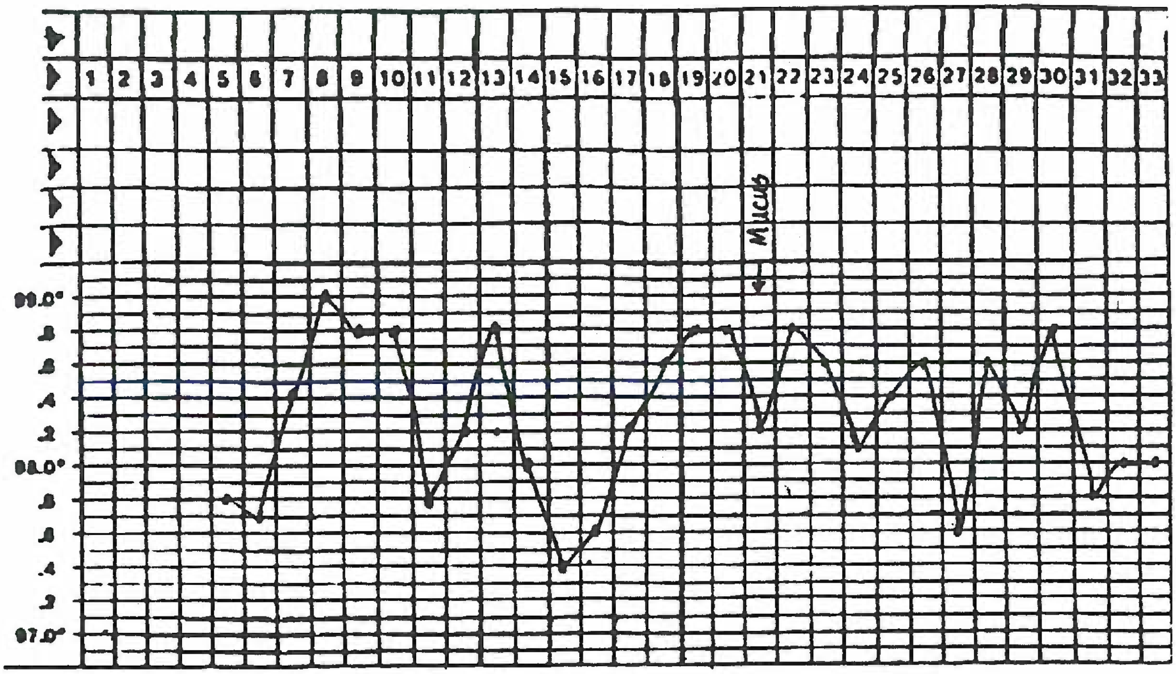


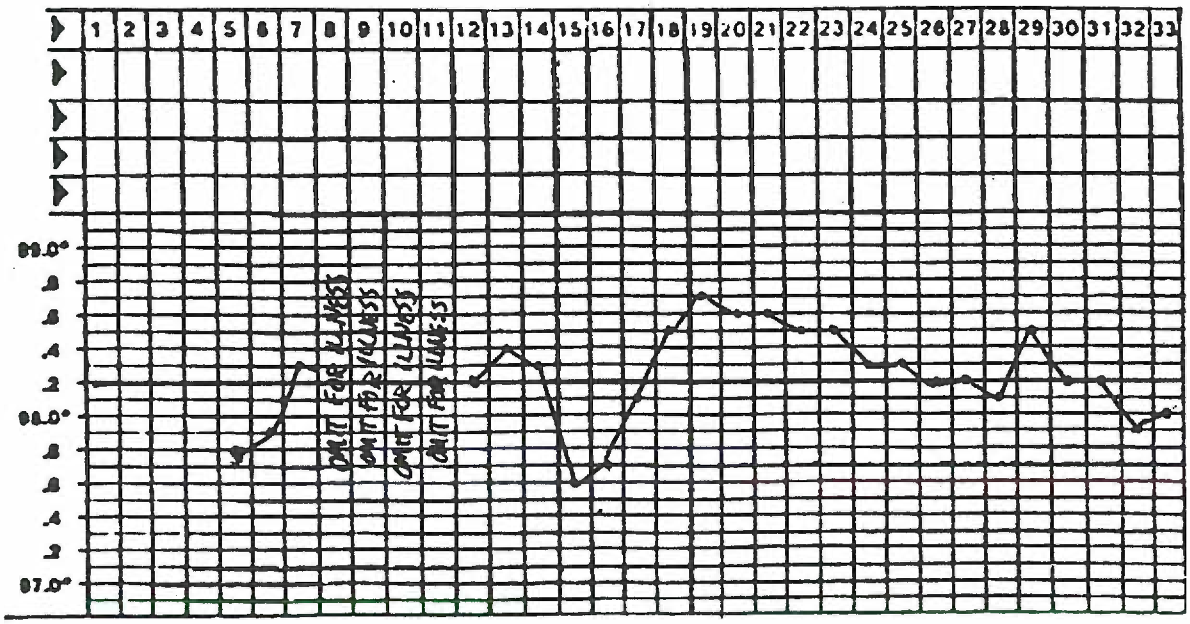
Smoothed Curve

average temperature = 98.1 F

Subject 2



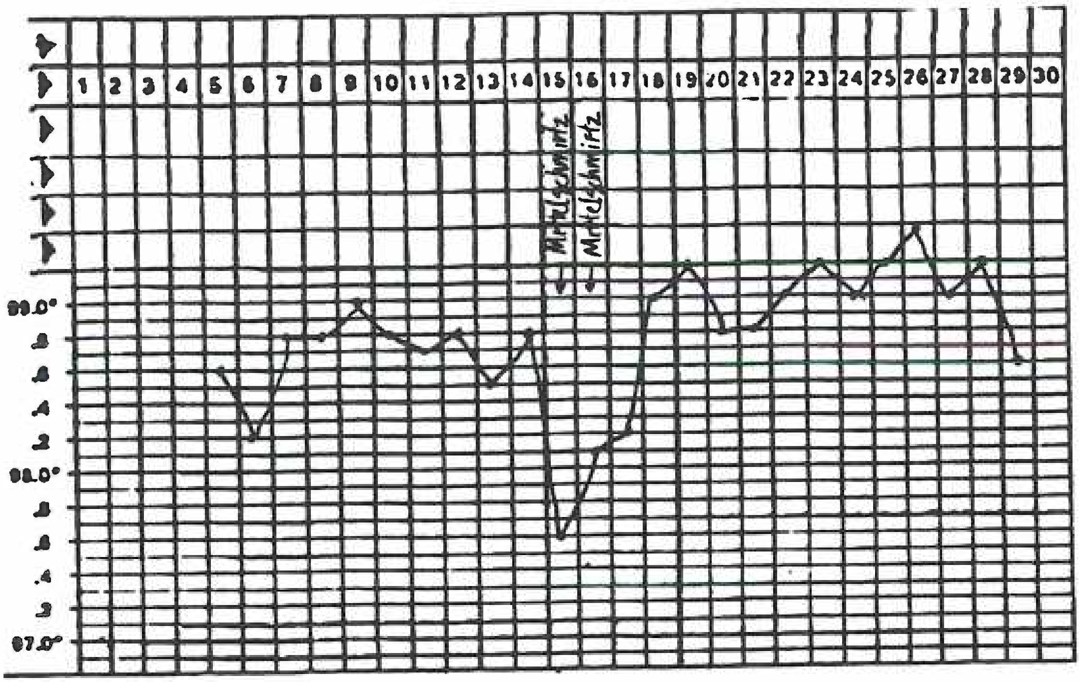
Original Curve



Smoothed Curve

average temperature = 98.2 F

Subject 3



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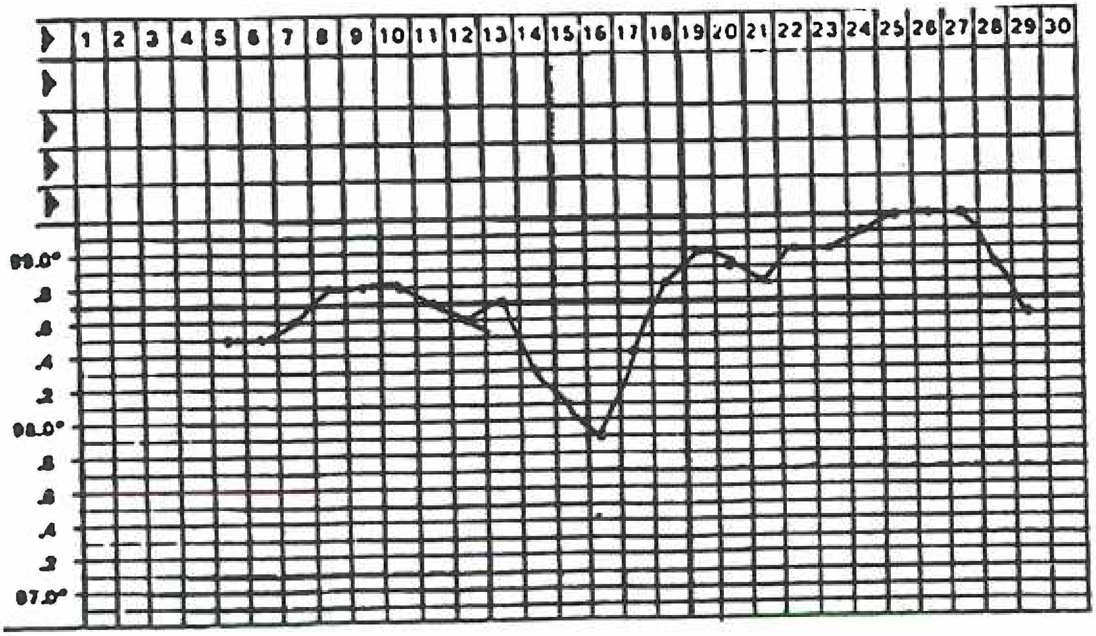
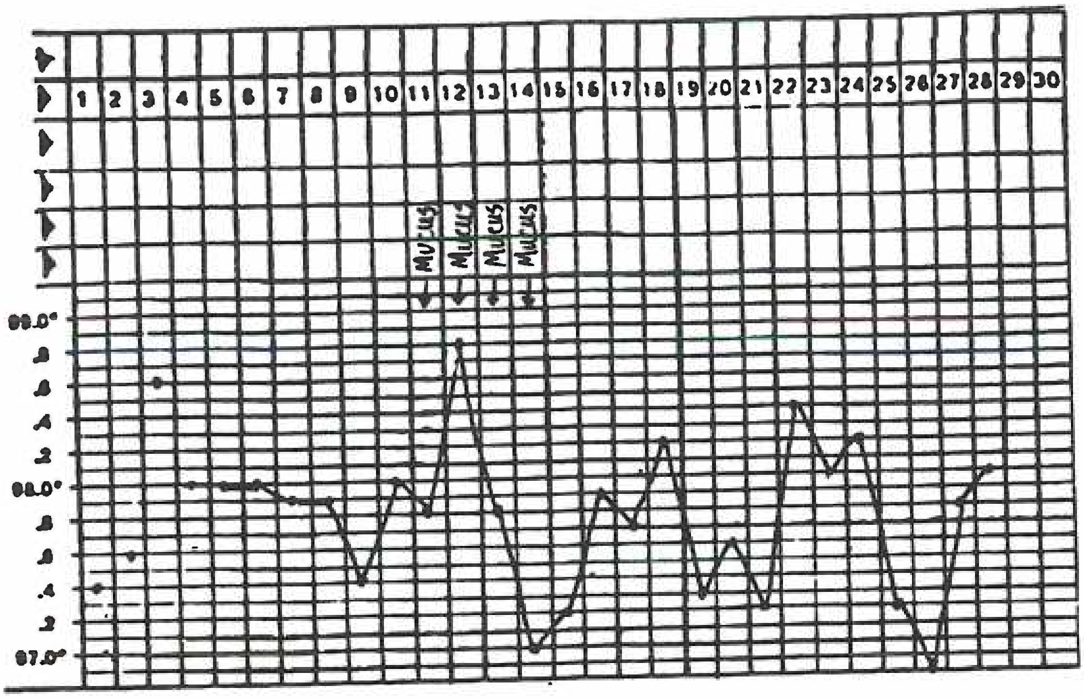


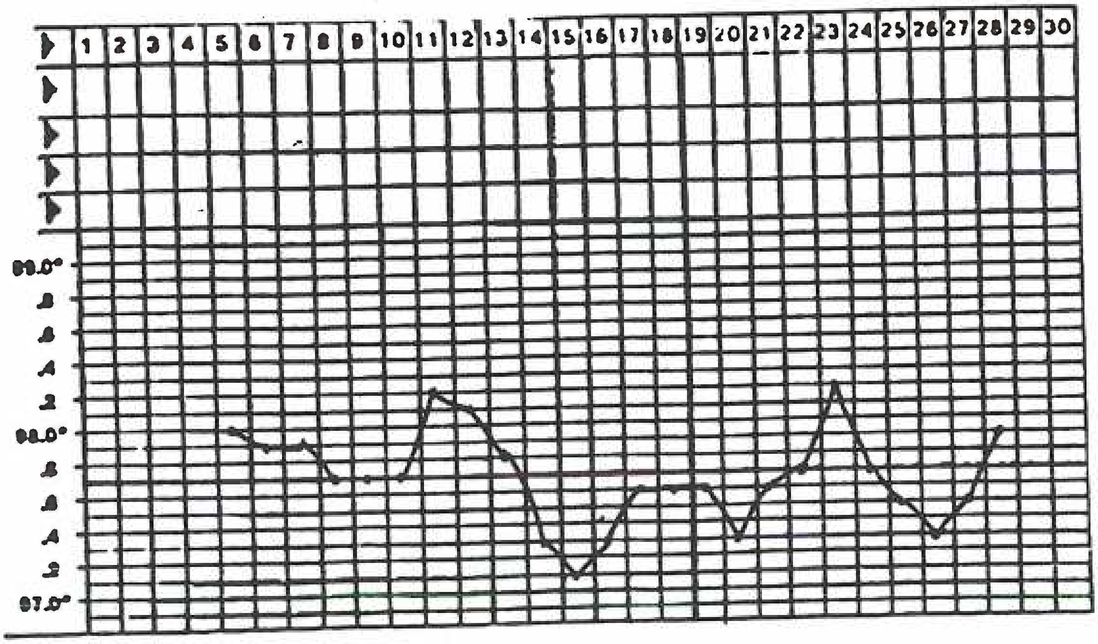
Smoothed Curve

average temperature = 98.7

Subject 4



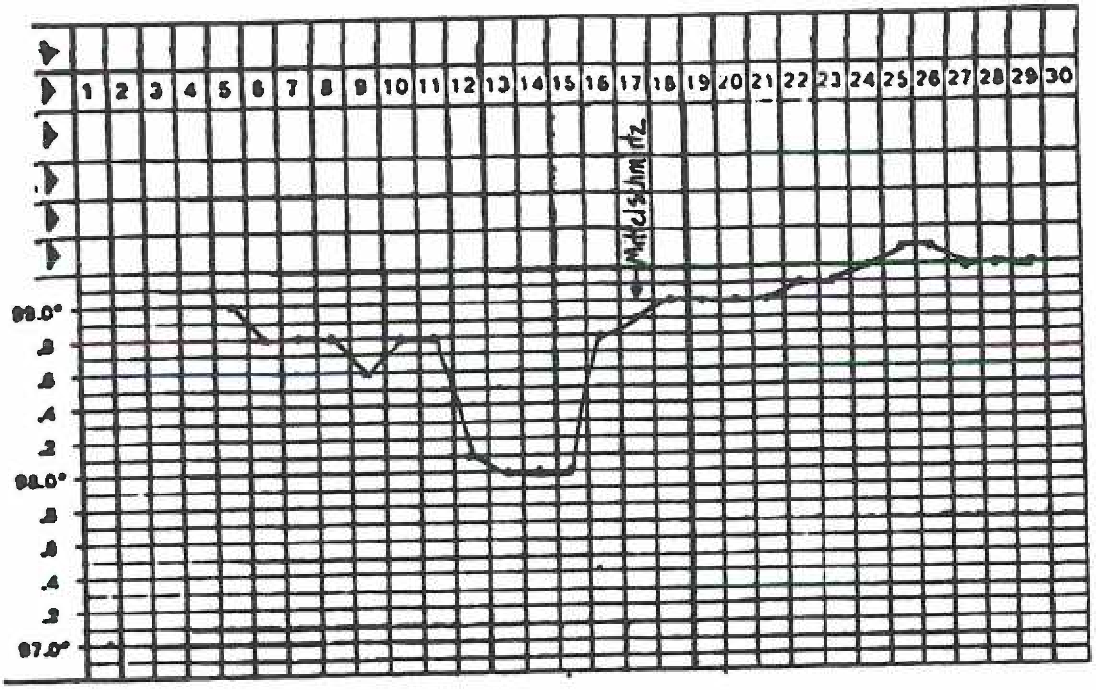
Original Curve



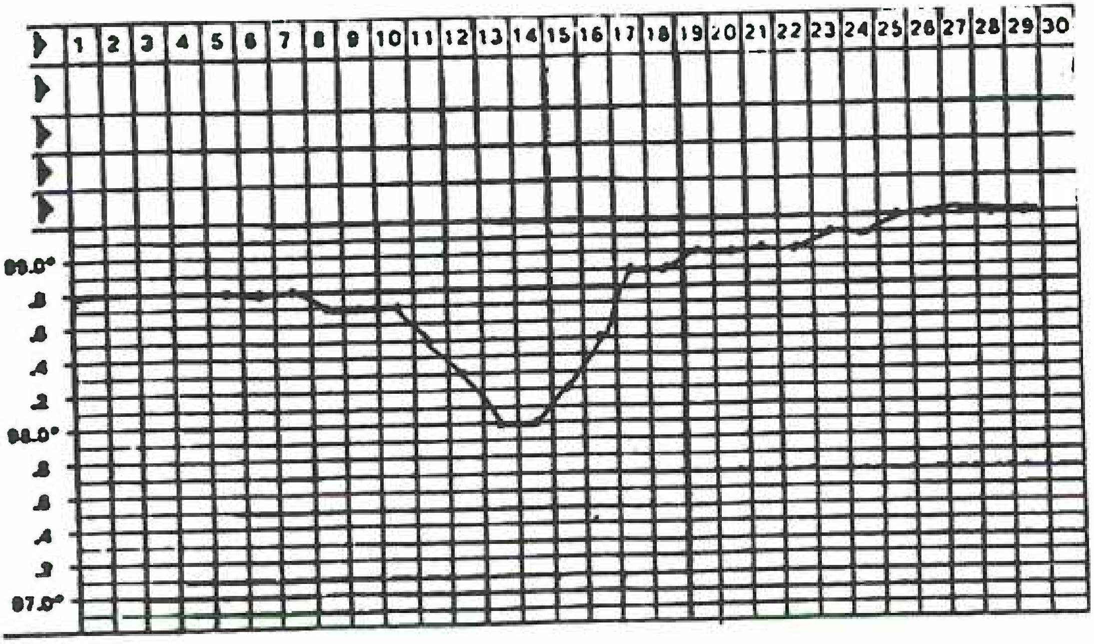
Smoothed Curve

average temperature = 97.7 F

Subject 5



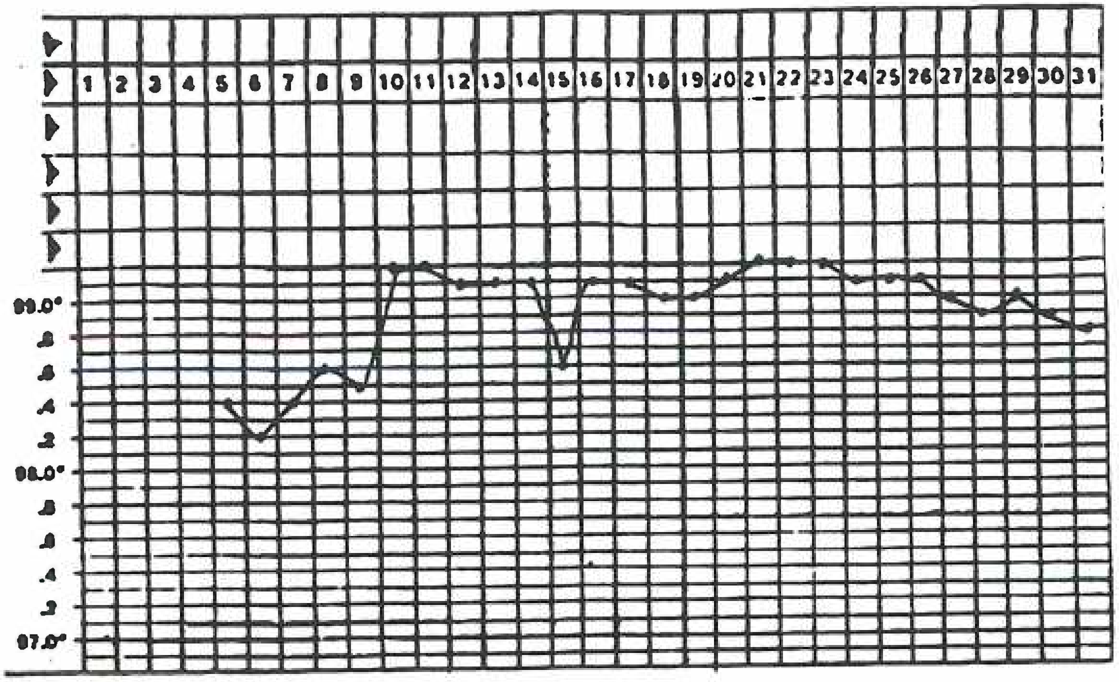
Original Curve



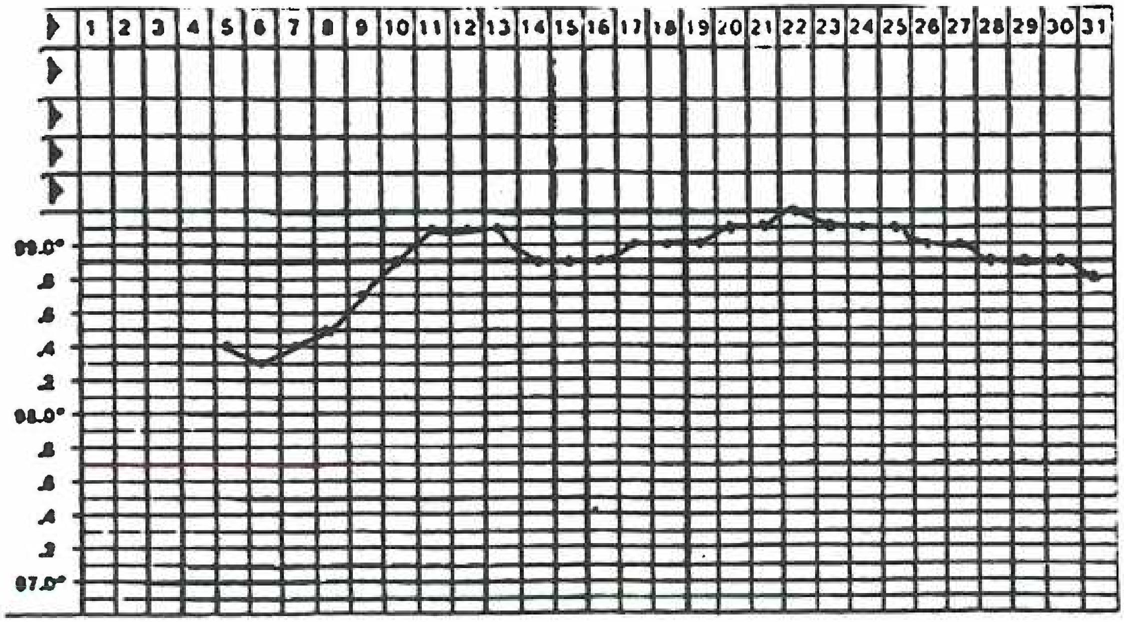
Smoothed Curve

average temperature = 98.8 F

Subject 6



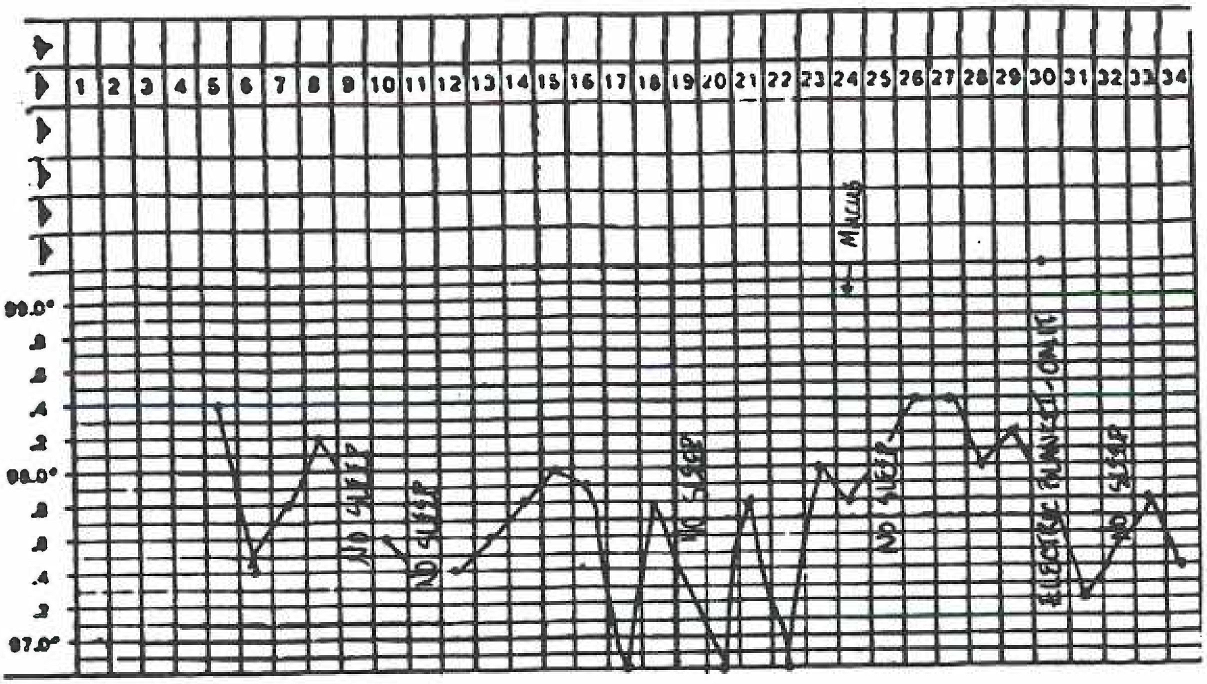
Original Curve



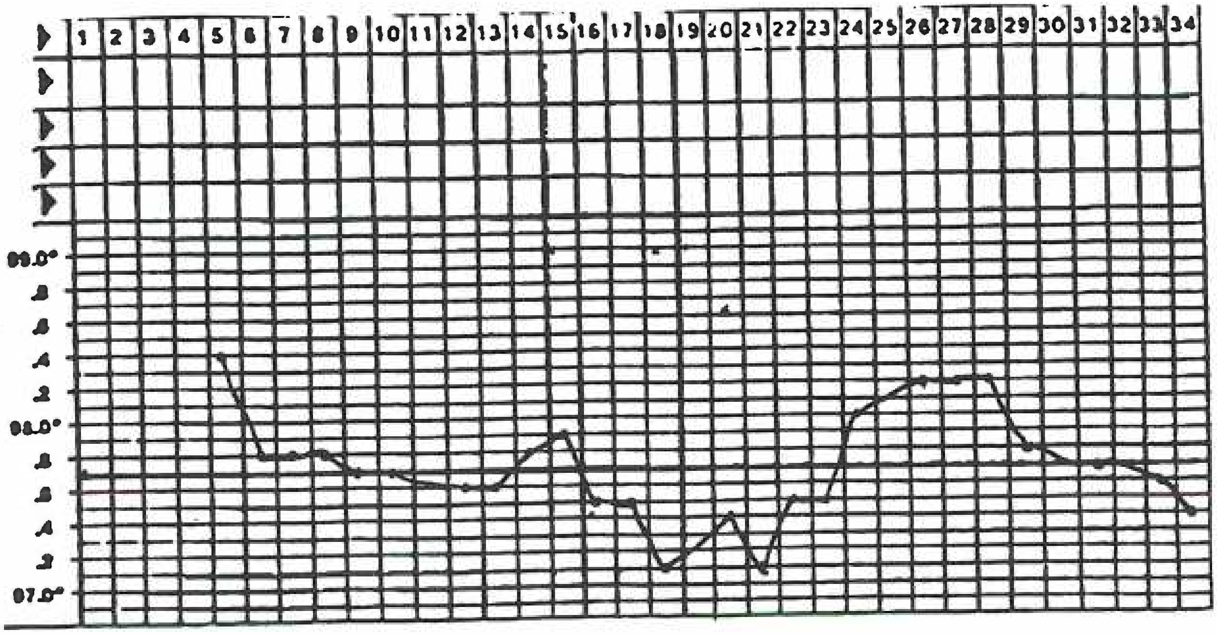
Smoothed Curve

average temperature = 98.9

Subject 7



Original Curve



Smoothed Curve

average temperature = 97.7 F

Subject 8

AN ABSTRACT OF THE THESIS OF

NANCY MACMORRIS-ADIX, R.N., B.S.N.

For the Master of Nursing

Date of Receiving this Degree: June 14, 1985

Title: Circadian Effects on Basal Body Temperature Graphs in Women Night Workers

Approved: [redacted]
Carol L. Howe, C.N.M., D.N.Sc., Thesis Advisor

The relationship between the circadian temperature rhythms of women night workers and basal body temperature (BBT) graphs was studied. Two research questions were examined: 1) Does the BBT graph predict ovulation in night workers? and 2) Does the BBT graph of night workers differ from the standard found in the literature?

Eight women night workers participated by taking oral temperatures upon awakening for one complete mentstrual cycle, providing microscope slides of vaginal mucus at midcycle, and completing a short demographic form. The graphs and slides were evaluated for evidence of ovulation (biphasic graphs and ferning mucus). This information was correlated using Fischer's Exact Test.

Research question 1 had no statistically significant results. Research question 2 had significant results as the BBT graphs of night workers were different from the standard found in the literature. All graphs showed marked daily variation of 0.2 - 1.0 F. In addition, the biphasic graphs all had a follicular phase rise not found in the literature.