3-1975

Daily Temperature Rhythm in Hospitalized Female Patients

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Graduate School

DAILY TEMPERATURE RHYTHM IN HOSPITALIZED FEMALE PATIENTS

by

Phyllis L. McElmurry

An Abstract of a Thesis

in Partial Fulfillment of the Requirements

for the Degree Master of Science

in the Field of Nursing

March 1975

ABSTRACT

The study was designed to determine the hour when temperature peaks occur in adult hospitalized females, and to find if factors such as age and natural or surgical menopause with replacement therapy affect the thermal circadian cycle. Previous studies indicated that the temperature peak occurs in afternoon or early evening, but there were no investigations to determine if aging, sex, or menopause affects the temperature cycle.

The sample included 62 female patients, 29 between 21 and 62 years of age, and 33 between 65 and 90 years. Each subject admitted to the study was screened against fifteen qualifying criteria. Some of the subjects were febrile. Data were collected at 10:00 (military time), and at two hour intervals from 14:00 until 22:00, from each subject for two consecutive days. For a given hour the temperatures were averaged for the two days, the hour of highest mean counted as the peak temperature. An oral IVAC electronic thermometer was used to measure all temperatures.

The findings supported the hypothesis that a significant number of peak temperatures would be missed by terminating measurements before 16:00. Ninety percent of the subjects' peak temperature occurred at 16:00 or after, seventy-five percent between 18:00 and 20:00.

No significant relationship was shown between age and the time of the temperature peak, nor did the findings indicate a difference in the peak temperature time between premenopausal, postmenopausal, and ovariectomized women.

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The format of this thesis conforms to the style suggested by Nursing Research since this manuscript is being submitted to that journal for publication.

Each person whose signature appears below certifies that this thesis in his opinion is adequate, in scope and quality, as a thesis for the degree of Master of Science.

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ACKNOWLEDGEMENTS

I wish to express deep appreciation to all those who helped me in making this study possible.

I wish to give special acknowledgement and thanks to Dr. Dorothy Martin, my committee chairman, for her many hours of patient guidance and encouragement. I would like to thank Ms. Lucile Lewis, and Dr. Elwood McCluskey, committee members, for their intellectual stimulation and unselfish generosity with their time and help.

For the time and explanation which was willingly given by Dr. Paul Yahiku and the department of biostatistics, I am most grateful.

Also I wish to express appreciation for the financial assistance from the Department of Health, Education and Welfare Nurse Traineeship Grant which sponsored most of my graduate education, including this study.

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INTRODUCTION

Temperature taking is one of the oldest procedures performed by nurses. Today temperature remains as one of the vital indices of sickness or health. Over the years the measuring instrument has been improved from a very crude device to a highly sensitive electronic instrument to aid the nurse. It has kept pace with the scientific age, but the nurse has more or less remained bound to traditional time schedules for measuring temperatures. However an increasing amount of data show that the daily thermal circadian cycle varies from person to person in relation to his rest and activity pattern and to a lesser extent other factors.

THEORETICAL BACKGROUND

Body temperature has a cycle with peaks and troughs about every 24 hours (Aschoff, 1969, p. 844; Kleitman and Ramsaroop, 1948, p. 16; Mellette, et al., 1951, p. 665; Felton, 1970, p. 56). If measurements of temperature are taken only during the trough part of the cycle, a fever, if present, may go undetected.

This rhythm persists in normal individuals throughout the day and during inactivity and disease, whether or not accompanied by a fever. Eating and exercise do not alter the circadian pattern. The cycle can be gradually inverted in about ten days when the schedule of rest and activity is reversed (Conroy and Mills, 1970).

The circadian temperature rhythm shows a crest associated with

wakefulness or activity and a trough associated with the period of sleep (Kleitman and Ramsaroop, 1948, p. 16; Kleitman, et al., 1937; Aschoff, 1969, p. 814). DeRisi (1968), Selle (1952), Smeltzer (1968), Sollberger (1965), and others have located the peak temperature between 17:00 and 20:00 (military time).

There are typical fever patterns associated with many disease states. Clinically, low grade fevers are as important as higher elevations of body temperature. Disorders such as rheumatic fever, tuberculosis, pulmonary embolism, subacute bacterial endocarditis, small bowel disorders, and low-grade urinary tract infections are only a few conditions that may be associated with low-grade fever.

A temperature recording taken at one time of the day may not indicate an elevation, whereas the same reading at another time of the day would indicate a fever. Therefore, not only is the temperature itself important to know but the relationship it has to the time of day and the patient's life style. This being so, it may well be necessary for nurses to revise their schedules of temperature measurement in order to get the most comprehensive and valuable information.

PROBLEM

Many hospitals follow schedules for temperature measurement based on tradition or the convenience of scheduling or staff. Often measurements are recorded only before 16:00 and/or after 20:00 ignoring completely the time period when the literature on circadian rhythms indicates that most people's temperatures peak (Walker, et al., 1965, p. 75; DeRisi, 1968, p. 251).

What variables may affect the thermal cycle? If sex influences it, as it does some other circadian rhythms, this factor would need to be considered in routines for temperature measurement. If a sex factor can be shown, is it related to female and male hormones? Would natural or surgical menopause alter the cycle? These questions were explored in this study.

HYPOTHESES

The purpose of this study was to determine the hour of circadian temperature peak in a group of hospitalized female subjects. Variables which were considered as possible influences on the circadian pattern were age and natural or surgical menopause.

It was hypothesized that:

1. A significant number of peak temperatures will be missed by terminating measurements before 16:00.
2. There will be a difference in the time peak temperatures that are observed in hospitalized female patients between those 18 to 64 years of age and those 65 years of age and older.
3. There will be a difference in the hour of peak temperatures between women who have gone through menopause and those who have not.
4. There will be a difference in the peak temperature time between ovariectomized women, and those with functioning ovaries.

ASSUMPTIONS

1. The information obtained from the patients' records was accurate, and the patients' responses to the questions were honest and correct.
2. The IVAC oral electronic thermometer was accurate within 0.2° F. as claimed by the manufacturer, and the data collector consistently followed the correct techniques for measurement as described in the operating manual.
3. The criteria used to screen the subjects were sufficient to sort out any unqualified subjects.
4. The restrictions imposed upon the subjects were sufficient to control any significant intervening variable in the experiment.

DEFINITION

The term "thermal circadian rhythm" refers to the daily variation of body temperature which is characterized by one peak and one trough about every 24 hours.

METHODOLOGY

Data were collected from hospitalized female patients in eight of the various medical and surgical units of a west coast medical center during March and April, 1972 (PST). The subjects were studied to determine the hour of peak temperature. They were under relatively constant conditions within the slight variations described. Room temperature throughout the hospital was approximately 70° F. to 75° F.

Relative humidity varied between 35 and 40 percent. Air flow was relatively constant with central air conditioning and heating and with no strong drafts on the patients. Windows in the hospital were kept closed. The patients were not under any strenuous exercise program. Clothing was light and allowed for normal loss of body heat. Food served was sufficient to meet the needs of each patient but not excessive. Lunch was between 12:00 and 13:00, and supper between 16:30 and 17:30.

Subjects were admitted to the study as they met the qualifications and not by any random sampling method. The screening criteria were that no subject would:

1. be less than 18 years of age.
2. have a neurological disorder.
3. be less than one day postoperative.
4. be disoriented to the extent she is unable to cooperate.
5. be undergoing renal dialysis.
6. have a normal schedule of daytime rest and night time activity.
7. be on antipyretic action drugs.
8. be in acute or chronic respiratory distress.
9. have a known disease condition that has an abnormal periodic fever pattern.
10. be having a blood transfusion reaction.
11. be undergoing hypothermia between 8:00 and 10:15.
12. be currently going through menopause, and still having occasional menstrual periods.

13. be receiving estrogens.

14. be pregnant.

15. be lactating.

Every female patient over age 18 years, admitted to the units where data were being collected, was screened for admission to the study. Febrile patients were included if they met all the criteria. If the subject met the criteria, if there were no plans for her discharge from the hospital within two days, or plans to change her treatment in such a way that it would disqualify her, she was included in the study.

The sample size was 62, with 29 patients between the ages of 21 and 62 years, and 33 between 65 and 90 years.

Fifteen to 25 subjects were studied at one time. However due to discharges from the hospital before all the data could be collected, or failure to maintain the restrictions of the study, about three-fourths of those admitted to the study were dropped.

According to the literature review the peak temperature is in the afternoon or early evening hours, 14:00 to 20:00. Therefore, temperatures were measured every two hours from 14:00 until 22:00 to enable the data to encompass the spread of peaking times. A reading was also taken at 10:00. Each subject was studied for two consecutive days. For a given hour the temperatures were averaged for the two days.

All temperatures were taken within 15 minutes of the hour. For example, all of the 14:00 temperatures were measured between 13:45 and 14:15. The only exception to this practice was at the 18:00 hours,

due to the fact that sometimes the meal trays were served late delaying measurements up until 18:30.

The 14:00 and 18:00 readings followed the noon and evening meals respectively. The temperatures were taken following the meals to measure any possible temperature increase caused by the metabolic response, or specific dynamic action of the meal. Measurements were delayed at least 10 minutes after fluids or foods were taken as well as after any hot or cold IPPB respiratory treatments. None of the subjects had smoked within 30 minutes of the measurements. The 10 minute waiting period was within the limits prescribed in the IVAC procedure manual. This brief waiting period is possible because of the IVAC thermometer technology and the location in which the reading is made, i.e. the artery under the tongue. This tissue in the area of an artery will normally return to its original temperature within 2 to 7 minutes.

Due to altered routines on Saturday and Sunday, data were not collected on these days.

All temperatures were oral, recorded on an electronic, battery operated IVAC thermometer which gives an accurate reading in about 20 seconds. The same thermometer was used throughout the study to control for any difference in instrumentation. The IVAC thermometer was kept charged at all times to guard against any false recordings. The procedure for taking temperatures was that prescribed by the IVAC Corporation (see Appendix B). One investigator collected all the data, thus preventing observer differences.

IVAC Corporation claims an accuracy to within 0.2° F. A

comparison study between the IVAC, two standard oral glass, and one glass rectal thermometer was done. Comparison readings were made in five different pools of water. All the thermometers were within a range of 0.2° F. of each other except in test #5 in which oral thermometer #2 was 0.4° F. lower than the others (see Table 1). The mercury thermometers were not used as a standard but merely to compare the accuracy of the IVAC thermometer with an accepted standard tool.

RESULTS

It was hypothesized that a significant number of peak temperatures would be missed by terminating measurements before 16:00. All but 7 of the 62 subjects peaked at 16:00 or after. The proportion of subjects peaking at 16:00 or after was .89 with a standard error of .04. The results support the hypothesis (see Figure 1).

The hypothesis that there would be a difference in the time of peak temperature between subjects 18 to 64 years of age and those 65 and older was not supported (t-test gave $P > .05$). The mean peak time for the 29 subjects in the 18 to 64 age group was at 18:17 and the mean peak time for the 33 subjects in the 65 to 90 year old group was 18:37 (see Figures 2 and 3). Also a regression analysis comparing age and time of peak temperature showed no significant relationship. Figures 4, 5, and 6 show the mean temperature distribution for each hour for all the 62 subjects, the 18 to 64 year old age group and the 65 to 90 year old age group respectively.

An analysis of variance, comparing the mean peak times between the premenopausal, ovariectomized, and postmenopausal subjects showed

Table 1

Comparison of the IVAC Thermometer and Three Conventional Mercury Glass Thermometers Made in Five Water Pools

Test #	IVAC	Rectal	Oral # 1	Oral # 2	Range
1	100.8°	101.0°	100.8°	101.0°	.2°
2	98.8°	98.8°	98.8°	98.6°	.2°
3	98.6°	98.6°	98.6°	98.6°	.0°
4	96.2°	96.0°	96.0°	96.0°	.2°
5	104.4°	104.4°	104.0°	104.4°	.4°

All measurements in degrees Fahrenheit.

Figure 1. Distribution of Mean Peak Temperature Times of All the 62 Female Subjects.

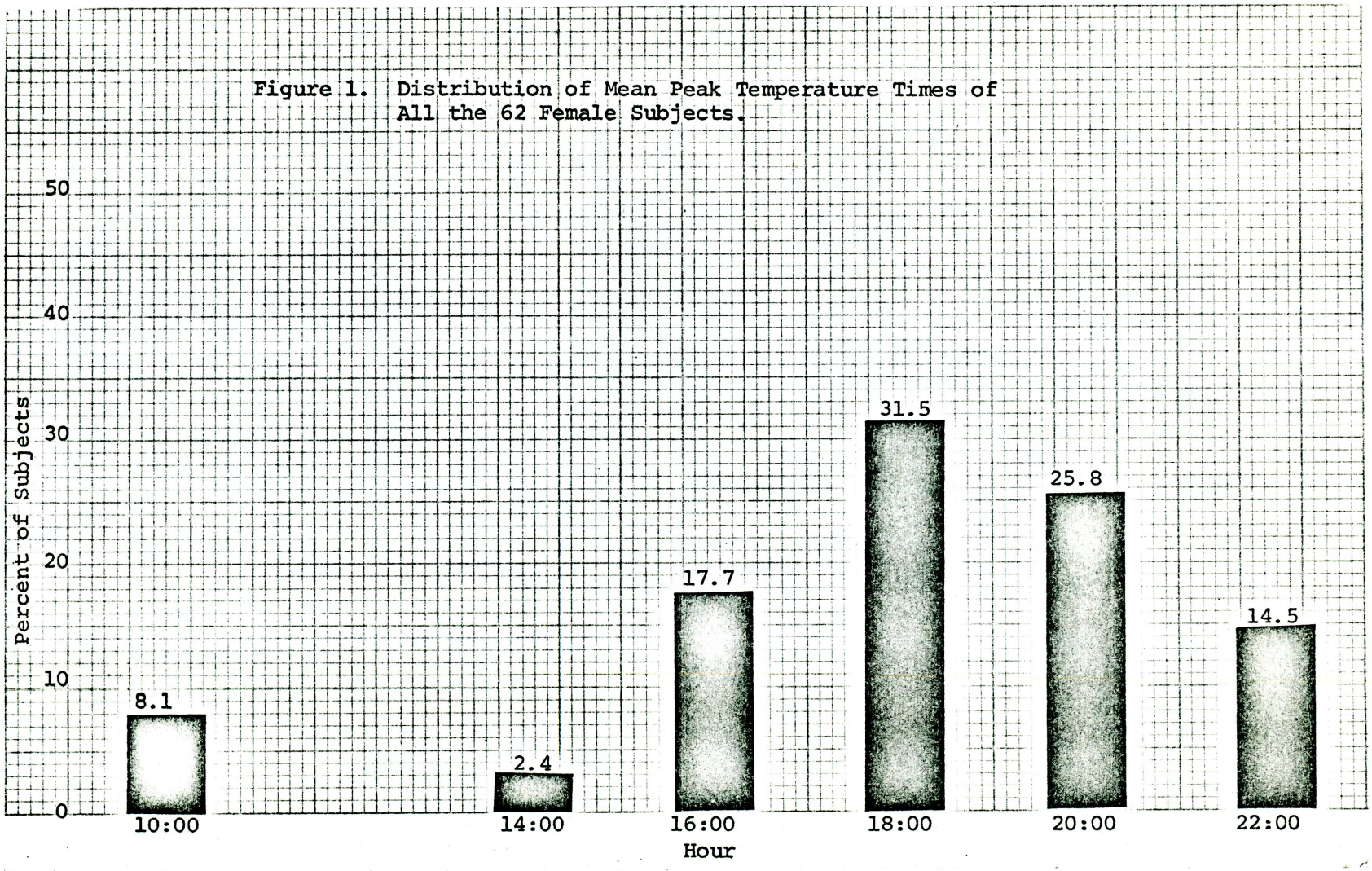


Figure 2. Distribution of Mean Peak Temperature Times of the 29 Subjects in the 18 to 64 Year Old Age Group.

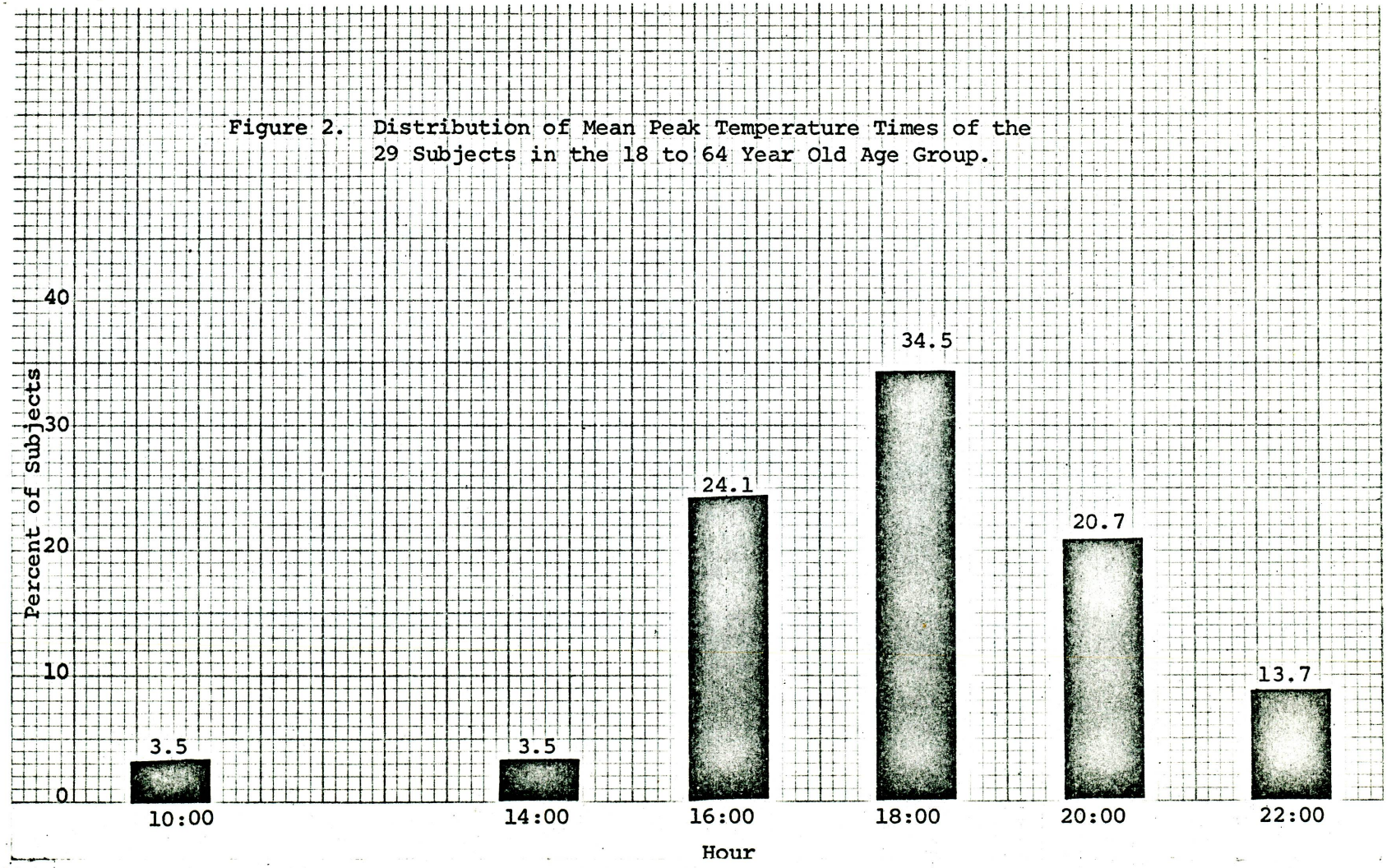


Figure 3. Distribution of Mean Peak Temperature Times of the 33 Subjects in the 65 to 90 Year Old Age Group.

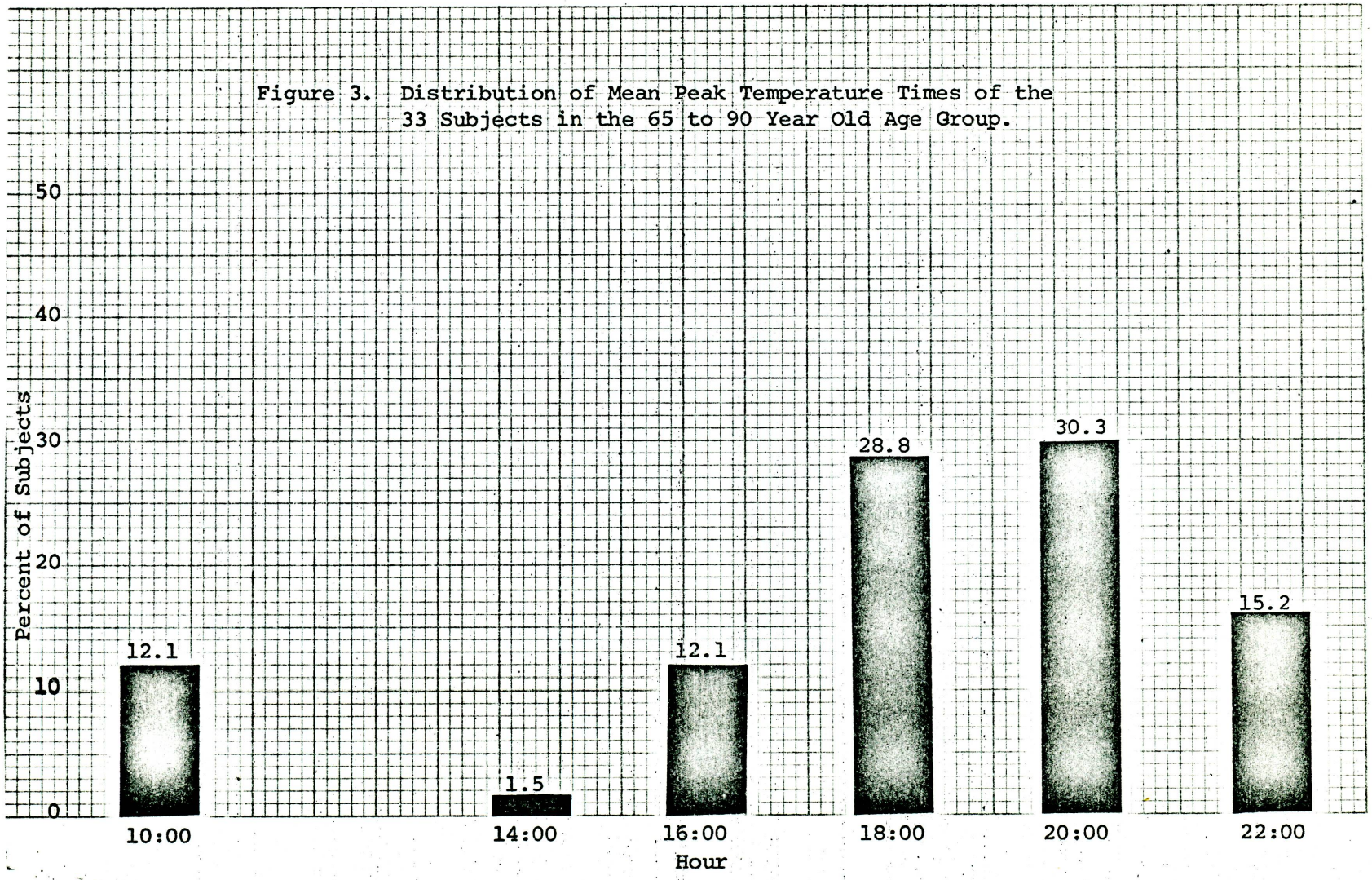


Figure 4. Scatter Diagram of Mean Temperatures of 62 Females.

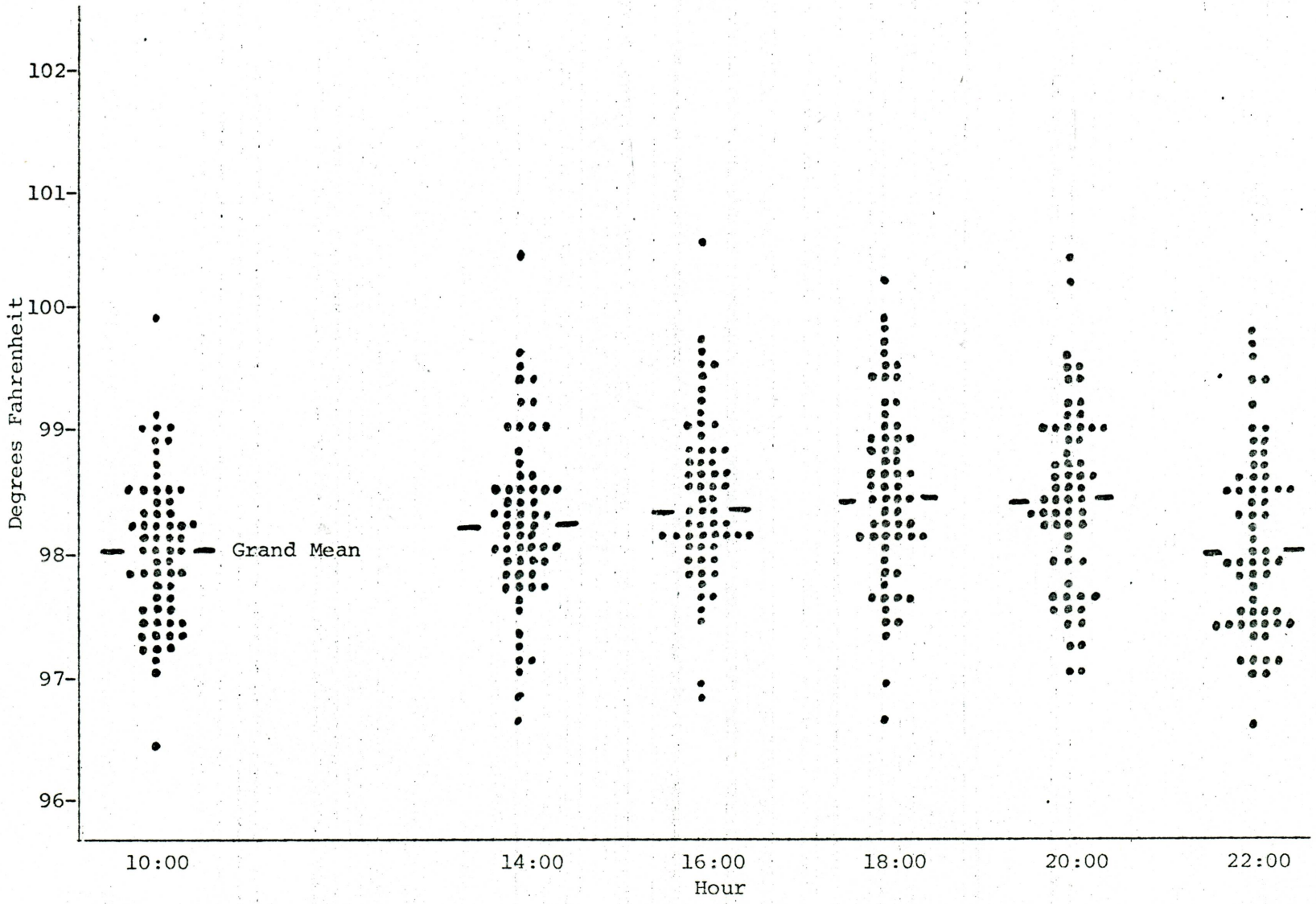


Figure 5. Scatter Diagram of Mean Temperatures of 29 Females in the 18 to 64 Year Old Age Group.

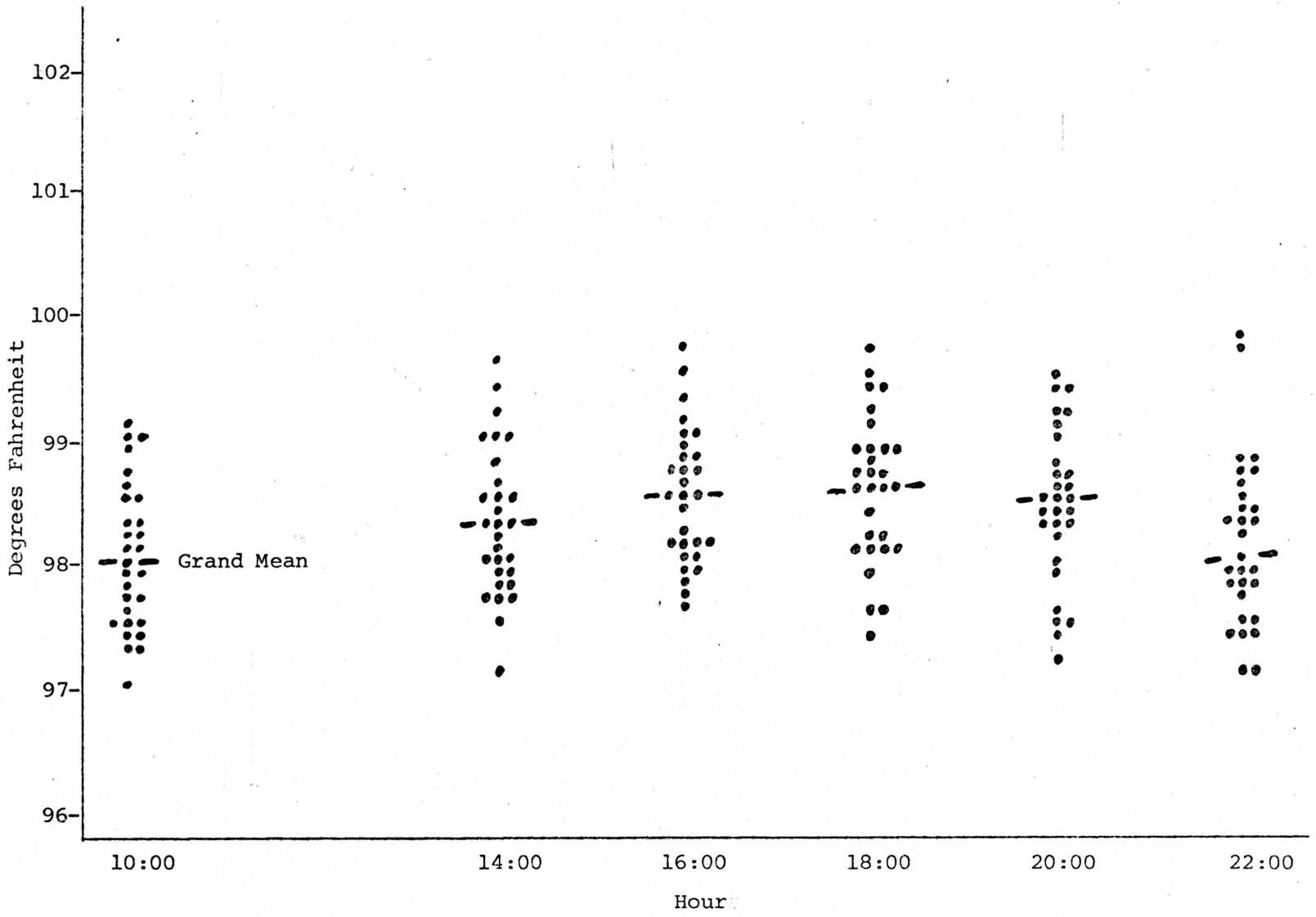
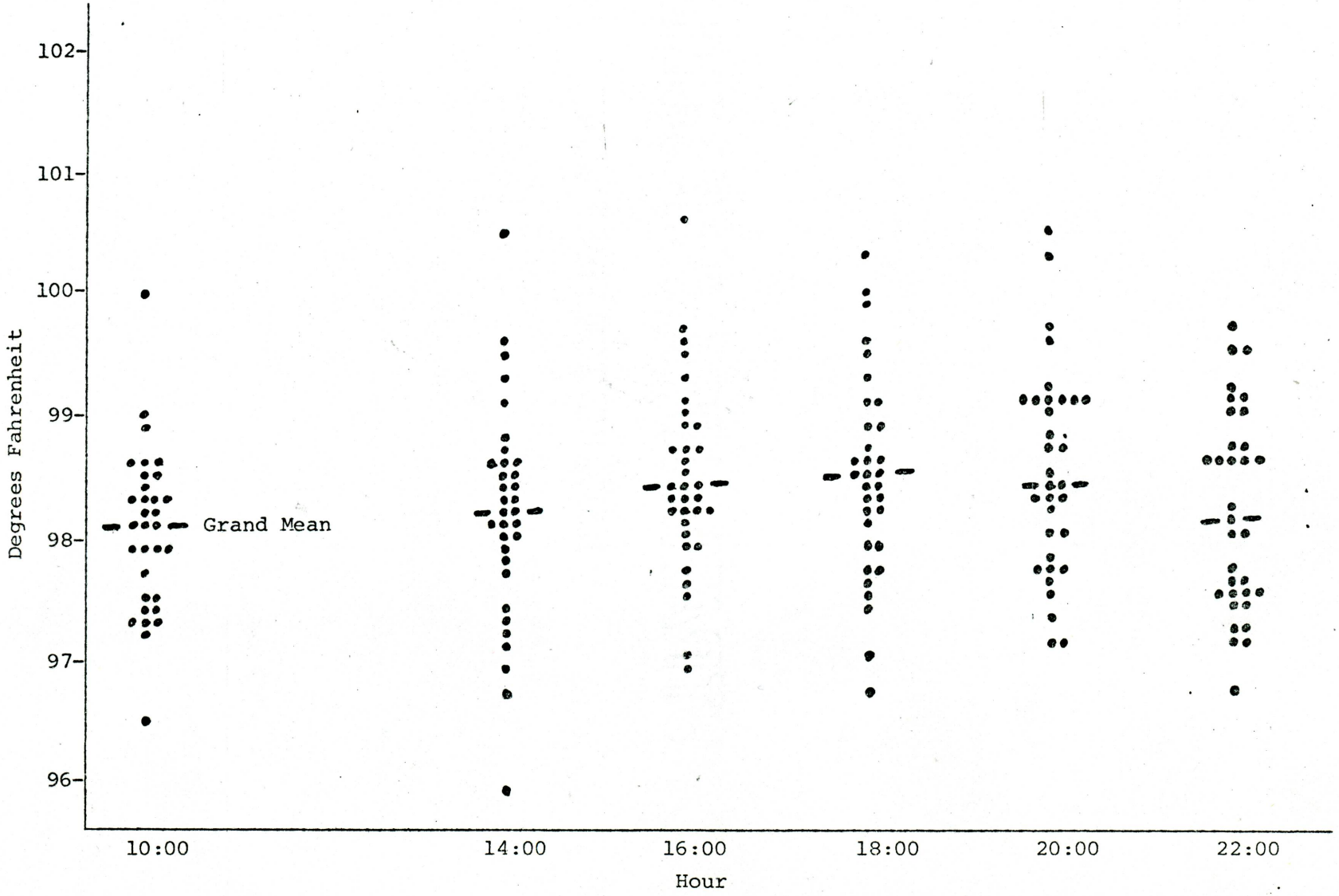


Figure 6. Scatter Diagram of Mean Temperatures of 33 Females in the 65 to 90 Year Old Age Group.



no significant difference ($P > .05$). (See Table 2.)

A desirable approach to determining the hour of peak temperature would be to use information contributed by temperatures other than just the highest reading. It would also be useful to incorporate the 10:00 readings taken in this study as part of the cycle. Therefore a sine-cosine curve fitting analysis was used as described by Batschelet (1965) to identify what will be called the crest hour. To achieve the desirable sensitivity by this method the minimum temperature for a given patient was subtracted as a constant from all of the temperatures for that particular subject.

This sine-cosine curve fitting was attempted for all 62 subjects and checked by plotting the readings. In a number of cases the time pattern was such that no meaningful peak could be discerned. This was especially true where the three readings nearest the calculated crest hour averaged 0.2° F. or less different from the three readings most remote from the crest hour. Only subjects with at least 0.2° F. difference, as described above, were used in further analysis. These 51 subjects are listed according to premenopausal (actual premenopausal and ovariectomized) and postmenopausal groups in Table 3. Their crest hours are shown in Figure 7 and illustrate the diversity in timing.

In an attempt to explain this diversity in hour of crest, the premenopausal and postmenopausal groups were compared by Watson and Williams' (1956) circular distribution test. Other variables were considered by covariance and multiple regression analyses. In the analyses of covariance, the premenopausal subjects were compared with the postmenopausal and the covariates considered were age, average temperature

Table 2

Comparison of the Mean Peak Time of Premenopausal, Postmenopausal, and Ovariectomized Subjects

	Number of Subjects	Mean Peak Time of Day	Standard Error
Premenopausal	10	17.6	± .6
Postmenopausal	48	18.7	± .3
Ovariectomized	4	17.5	± .5

The values for mean peak time of day are given to the closest tenth of an hour.

Table 3

Crest Temperature Hours for 51 Female Hospitalized Patients According to Pre- and Postmenopausal Groups and Other Variables

Patient Number	Age	Average Temperature	"Half-night" Hour	Crest Hour
Premenopausal				
1	32	97.9	245	1607
7	49	99.0	215	1731
10	24	98.7	315	1946
16	30	99.2	315	1348
36	36	98.5	145	1423
44	42	98.4	400	2029
59	23	98.7	200	1140
61	26	98.8	200	1432
Ovariectomized				
5	48	98.2	400	1844
6	34	98.1	200	1912
8	45	98.3	045	1753
35	40	97.8	130	1756
Postmenopausal				
3	55	98.8	107	1239
4	49	97.8	152	1821
12	73	98.7	307	1916
14	81	100.1	145	1343
15	79	98.7	352	2010
17	83	97.6	252	1219

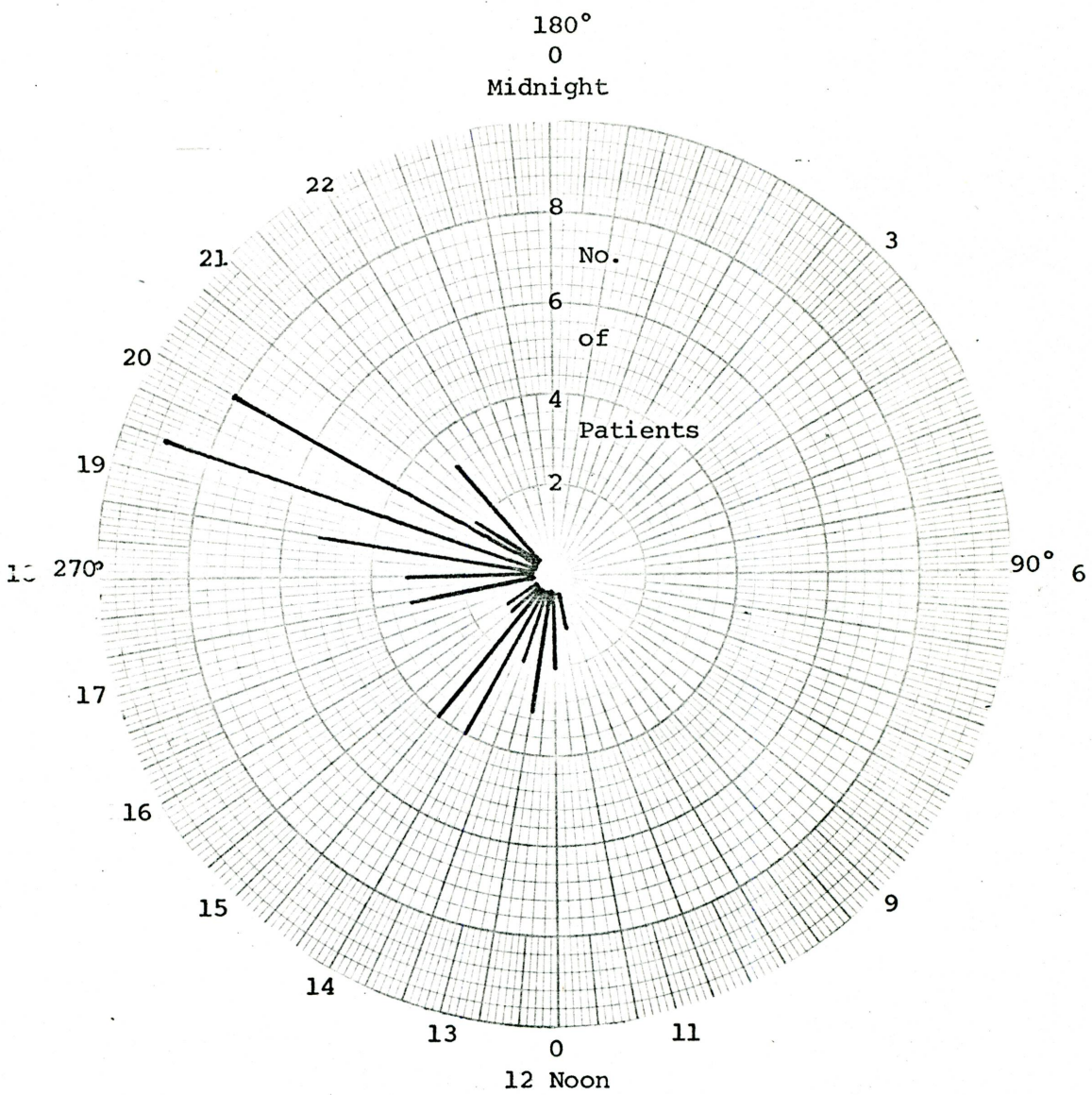
Table 3 (Continued)

Patient Number	Age	Average Temperature	"Half-night" Hour	Crest Hour
18	49	97.8	200	2133
19	71	98.4		2126
22	50	98.8	230	1823
23	75	99.5	315	1717
26	74	97.5	230	1409
27	76	98.3	100	1321
28	69	98.8	352	1930
29	72	98.5	252	2016
30	88	99.4	230	1942
31	53	98.9	230	1856
32	75	98.6	315	2102
33	82	99.2	500	1359
34	60	99.3	352	2014
37	81	97.4	115	1711
38	37	98.0	400	1848
39	52	99.4	152	2055
40	52	98.4	145	1946
41	83	98.6		2014
43	74	98.7	600	1911
45	59	98.9	245	1503
46	81	97.5	200	1919
47	62	97.7	215	1312
48	69	98.0	345	1431

Table 3 (Continued)

Patient Number	Age	Average Temperature	"Half-night" Hour	Crest Hour
50	90	97.7	200	1904
51	81	97.9	245	1819
52	86	98.2	230	1918
53	84	99.5	122	1934
54	80	98.0		1956
55	65	97.7	330	1206
57	56	97.9	500	1425
58	65	97.1	307	1235
60	72	98.6	337	1918
62	71	98.2	245	1224

Figure 7. Crest Temperature Hours for Fifty-one Female Subjects.



40 Minute Intervals	N		
1101-1140	1	1621-1700	0
1141-1220	2	1701-1740	3
1221-1300	3	1741-1820	3
1301-1340	2	1821-1900	5
1341-1420	4	1901-1940	9
1421-1500	4	1941-2020	8
1501-1540	1	2021-2100	2
1541-1620	1	2101-2140	3
			51

(determined from the six readings made each day), and "half-night" (the midpoint between the patient's stated customary bedtime and rising time). The last variate was not available for three of the 51 subjects, so the sample size for this analysis was reduced to 48. This same sample was used for the multiple regression, for which the pre- versus postmenopause grouping was entered simply as the fourth independent variable. Also used in both types of analysis was a smaller sample of 36, limited to those subjects whose near crest-hour readings averaged more than 0.3° F. different from the readings remote from the crest hour.

The pre- and postmenopausal groups were not shown to differ significantly by any of the above three types of tests, and neither the multiple regression nor any of the covariate F values were significant. All P values were greater than .10, although group average temperature and "half-night" P values were less than .25.

DISCUSSION

Within the limited segment of the day studied here (10:00 and 14:00 to 22:00) over half of the actual peak temperatures were at 18:00 or 20:00. The 18:00 high was probably not due simply to the fact that it was soon after a meal since the 14:00 reading was also after a meal. These findings were consistent with other research on the subject. Only 2.4 percent occurred at 14:00. Some researchers have noted a dip in the temperature early in the afternoon (Kleitman and Ramsaroop, 1948; Conroy and Mills, 1970; Smeltzer, 1968). Five subjects' (8.1 percent) temperatures peaked at 10:00. Mellette and associates (1951) found a somewhat later peak time among a group of 22 medical students; 20:49

for the male subjects and 22:49 for the females. Perhaps the peak temperatures occurred at a later hour due to altered routines of rest and activity for these students. Felton (1973) found the mean peak time for a group of 39 active and employed nurses who worked the 7:00 to 15:30 shift to be at approximately 15:00. This activity schedule is somewhat earlier than many people observe.

Though little is reported in the literature regarding the effect of age on the thermal circadian rhythm, Lobban and Tredre (1967) found a normal phase and amplitude variation in a group of 24 elderly ambulatory subjects. Cahn and associates (1968) found dissociation among several circadian patterns in older male subjects but no significant change in the thermal circadian cycle. They questioned if the dissociation was due to age or poor health. It has been suggested that there is degeneration of the thermal circadian rhythm with advancing age, however, this has not yet been demonstrated. This study showed no significant relationship between age and the time of peak temperature.

No research has previously been reported exploring the relationships between female hormones and the circadian cycle. Neither the postmenopausal nor ovariectomized group showed any significant difference in actual peak temperature time from the premenopausal group.

Data were analysed by several types of statistical tests in an attempt to explain the diversity in hour of crest as identified by sine-cosine curve fitting. Although all of the P values were greater than .10, this does not mean that the factors explored--effect of

ovarian hormones, age, average temperature or "half-night" hour may not be important in explaining diversity in crest time. The premenopausal sample was small (eight of the 51 patients), the stay in the hospital had probably already shifted the "half-night" hours together somewhat for the various subjects, and low-grade fever and other ailments of some of the patients may have influenced their temperature cycles. P values of less than .25 in all comparisons except age indicate possible trends that should be explored in other populations.

A sex difference is not known to exist with regard to circadian rhythmicity or body temperature. DeRisi (1968), using 100 hospitalized males, ranging in ages from 20 to 65 years, as subjects, found that 95 percent of the men had their peak temperature at 18:00. She measured temperatures only at four hour intervals beginning at 2:00 and ending at 22:00. Data from my study can be arranged for comparison by counting only the 10:00, 14:00, 18:00 and 22:00 readings for the 18 to 64 age group; 69 percent of the peak temperatures would then fall at 18:00.

CONCLUSIONS

Most peak temperatures will be missed by terminating measurements before 16:00. No significant difference was shown in the time of peak temperature occurrence in the 18-65 and the 65-90 year groups, nor between the premenopausal, postmenopausal and ovariectomized groups.

IMPLICATIONS

Some implications for nursing practice are suggested as a result of this study:

1. The nurse should consider the circadian rhythm of body temperature when establishing routines for temperature measurement so that for patients on usual rest-activity pattern of night time rest and day time activity, a measurement would be taken between 16:00 and 20:00, preferably between 18:00 and 19:00.
2. The nursing history should include questions that would guide the nurse in determining the patient's normal circadian pattern, so that a temperature measurement could be taken at a time when the patient's temperature peak would most likely occur.
3. Measuring temperatures at the peak of the circadian thermal rhythm would enable better detection of fevers, particularly low-grade fevers.
4. Fewer temperature measurements would need to be taken if the circadian patterns of patients were determined. Efficiency and accuracy could be improved.

RECOMMENDATIONS FOR FURTHER STUDIES

It is recommended that this study be replicated comparing subjects in good health with those considered to be in poor health. The study could also be repeated using identical methodology with both a male and female population, looking for differences, if any, in the time of peak temperature. Replication of the study, with a more even distribution among the premenopausal, postmenopausal, and ovariectomized groups, might yield data more appropriate for generalizations to a larger population.

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APPENDICES

APPENDIX A

LITERATURE REVIEW

Thermal Circadian Pattern

The body temperature of normal individuals who are on routine daily schedules fluctuates systematically and significantly around a 24 hour time period. Temperature varies about a degree or two within 24 hours with great regularity (Luce, 1971, p. 44). This rhythm persists during inactivity throughout the day and in disease whether or not accompanied by fever. It is not dependent on eating or exercise. The cycle can be gradually inverted in about ten days more or less when man reverses his schedule of activity and rest (Conroy and Mills, 1970). When the environmental routine is changed rapidly physiological time does not immediately coincide with astronomically determined local time (Mills, 1966, pp. 135-136; Conroy and Mills, 1970, p. 24; Felton, 1973).

The circadian temperature rhythm shows a crest, associated with wakefulness or activity, and a trough, associated with the period of sleep (Kleitman and Ramsaroop, 1948, p. 16; Kleitman, et al., 1937; Aschoff, 1969, p. 844; Mellette, et al., 1951, p. 655; Felton, 1970, p. 56). Body temperature does not peak until afternoon or early evening in persons who are on a schedule of day activity and nocturnal rest. Baerensprung, in 1851, fixed the time of lowest body temperature at 4:00, and the maximum temperature as being between 18:00 and 19:00. Damrosch observed two years later that the temperature rose from 7:00 to 10:00 and then fell until 13:00 before reaching maximum at 17:00 (Conroy and Mills, 1970, pp. 18-19).

DeRisi (1968), Selle (1952), Smeltzer (1968), Sollberger (1965), and others have located the peak temperature between 17:00 and 20:00. Mellette and associates (1951) found the peak as late as 20:49 and 22:49 in a group of male and female medical students respectively. In a study of a group of 39 employed nurses in Hawaii working the 7:00 to 15:30 shift, who ranged in ages from 21 to 45, Felton found their mean peak temperature to occur at 15:00 (1973).

Age

There are not many studies reported exploring the relationship between age and rhythm. Newborn infants have no circadian variation of body temperature during the first few weeks of life. Their control of temperature is imperfect, and may show a significant temperature change after crying, or after a cold bath. There is a gradual increase in the temperature range, and in the regularity of the daily curve during the first year of life. During the second year the adult type curve becomes definitely established (Conroy and Mills, 1970, p. 118; Reinberg and Ghata, 1964, pp. 108-109; Kleitman, et al., 1937, p. 54).

Bryan and Overall (1970) studied 143 hospitalized subjects ranging in ages from three months to 21 years with a peak distribution of nine to 12 years of age. They used body temperature, pulse rate, respiratory rate, systolic and diastolic blood pressures as indicators. There was a highly significant correlation between age and mean levels of the physiological measurements. These data demonstrated a peak composite circadian periodicity at six years of age, with a tendency to form a plateau at about 16 years of age. These researchers suggested that maintenance of periodicity was a function of neurological maturation,

cycles (Mellette, et al., 1951). DeRisi's (1968) study on 100 male hospitalized subjects from 20 to 65 years of age showed that 95 percent of her subjects peaked at 18:00.

A sex difference was suggested as a result of a study on 50 young children who were hospitalized and febrile. There were 25 males and 25 females, ranging in ages from seven to 13 years. The researchers concluded that the length of time required to take an accurate rectal temperature was longer with the female subjects. The reason for this variation was not clear. There was no significant difference in the length of time required to get accurate oral recordings, nor significant difference in the time of peak temperature between the sexes (Nichols, et al., 1972).

Female Hormones

The variations in the basal body temperature of normally menstruating women are due to the ovarian hormones, estrogen and progestogen. Temperature curves which appear normal can be demonstrated in overiectomized women by proper cyclical use of these hormones (Palmer, 1950, p. 158).

Callis and associates (1922) reported a study done on 16 active and healthy female students that showed that the premenstrual temperature was the highest temperature of the cycle. The menstrual and post menstrual were intermediary, showing an increase until the next menses. This applied for both morning and evening temperature, thus producing a general upward or downward shift in the thermal pattern. In normal menstruating women the temperature is at a relatively low level during the first part of the cycle with a drop of about 0.4° F. to a minimum

and that the infant would not maintain the maternal periodicity until a critical amount of neurological maturation has occurred (Bryan and Overall, 1970). This suggestion was supported by Hellbrugge's studies that circadian periodicity developed later in premature infants than in children born at term (Hellbrugge, 1960).

Conflicting reports are found as to the continuance of a distinct thermal periodicity into senescence. Twenty-four ambulatory subjects, 64 to 88 years of age, showed a clear cut circadian variation in temperature with normal phase and amplitude variation (Lobban and Tredre, 1967). Older persons have a lack of control due to a decrease in activity and poor circulation, thus preventing their bodies from compensating well to their changed environment (Reinberg and Ghata, 1964, pp. 108-109). Cahn, et al. (1968) reported a study that dissociation was more common in older subjects. Stephens (1968, p. 80) felt that relative non plasticity of circadian rhythms was seen at either end of the age continuum since both groups have difficulty in adapting to changed life circumstances.

Sex

There is no strong evidence reported to date that the pattern of temperature varies with sex. Of 22 healthy medical students the maximum rectal temperature for the 11 male subjects averaged 38.32° C. (101.° F.) at a mean time of 20.49 hours while the corresponding values for the females were 38.36° C. (101.° F) at 22.49 hours. The sex difference was moderately significant statistically, with respect to the following variables: level and time of minimum temperature range; time of maximum temperature; mean rate of change per hour; and sleep and wake

temperature at the time of ovulation with a sharp rise to a relatively high level (up 0.5° F. to 1.8° F.) remaining until the next menses when the temperature drops abruptly. Before menarche, after menopause, and in ovariectomized women, and in males, similar fluctuations are not found (Selle, 1952, p. 11; Ziegel and Blarcom, 1964, pp. 29-30).

If conception occurs, the temperature rises significantly and reaches its highest level within the next several days. This high level is maintained throughout pregnancy (Palmer, 1950; Kleitman and Ramsaroop, 1948, p. 17). It is no longer diphasic, and its variations from day to day are less than at any time during a nonpregnant state (Palmer, 1950, p. 157). Body temperature is lower during lactation than during the menstrual cycle (Kleitman and Ramsaroop, 1948, p. 19). After menopause the estrogen production gradually decreases until it is almost negligible. FSH is produced in increasing and continuous quantities. The normal monthly pattern is no longer seen (Guyton, 1969, p. 1144). Estrogens given to normal or ovariectomized females produce a drop in the basal body temperature; progesterone produces an increase (Selle, 1950, p. 11).

The body temperature of women has been shown to have a circadian variation sufficiently great to obscure completely the diphasic or monthly fluctuations of body temperature if the time factor is not observed carefully (Palmer, 1950, p. 160; Conroy and Mills, 1970, p. 21).

Other Influences

A remarkable quality of the thermal circadian rhythm is the temperature independence. The metabolic processes usually speed up

with rising temperature, but this does not occur when the temperature rises due to circadian influences (Sollberger, 1965, p. 117).

Body temperature depends on a balance between heat production and heat loss. Heat production usually varies circadianly. Factors that may interfere with heat loss due to decreased evaporation are excessive clothing, high levels of humidity, and very warm climates without much movement of air. Strenuous exercise can raise the temperature significantly for a period of time, due to an increase in metabolic rate above normal (Selle, 1952, p. 16).

Ingestion of food increases heat production. About an hour after the ingestion of food the metabolic rate rises above the basal level. A maximum level is attained around the third hour, and maintained at this level for several more hours. This action is known as the specific dynamic action of food. Protein causes the metabolic rate to rise to a higher level and for a longer period of time than do carbohydrates or fats (Guyton, 1969, p. 880). In spite of food intake, exercise, and environmental conditions, the circadian rhythm is overriding.

APPENDIX B

IVAC TEMPERATURE MEASURING PROCEDURE

Perform the following steps to obtain an ORAL temperature reading:

1. Check that the oral (blue top) probe connector is properly seated in its receptacle on the base of the thermometer. If this connector is not inserted, the display will read 90.0° F. when the thermometer is turned on, then immediately jump to 108° F.
2. Remove the probe from its stored position and insert it into a probe cover. Hold the probe by its blue collar so that you are not pressing on its top. It is not necessary to touch the probe cover with your hands. The probe covers are packaged ten to the box for easy handling and to assure a clean, ready-for-use condition at the time of insertion.
3. Depress the pushbutton to turn on the thermometer. The button will stay down, don't hold your finger on it. The readout will display 90.0° F. and after the insertion will count up to the patient's temperature in about 15 seconds. A small light, just to the right of the temperature reading, will come on when the patient's temperature is reached. The pushbutton will stay in the down position and the temperature will remain displayed (even after the probe is removed) until the button is pressed a second time to turn the thermometer off.
4. Slowly insert the covered probe until its metal tip is at

the base of the tongue.

NOTE

The method that has proved most effective is to have the patient open his mouth slightly with his tongue relaxed against the lower teeth. While holding the probe loosely between the thumb and index finger as you would hold a dart, insert the probe under the front of the tongue so that its metal tip touches the tissue where the tongue meets the gum line. SLOWLY, take 4 to 7 seconds, slide the tip back along the inside of the jawbone until it is back as far as possible and against the base of the tongue. Then, hold the probe motionless until the read light comes on. When properly executed, this technique provides a computed temperature in about 15 seconds.

When it takes longer than 20 seconds for the read light to come on, or when the patient response does not allow the proper technique, use the extended reading mode incorporated in the thermometer for conventional temperature taking. SIMPLY depress the pushbutton twice after the read light comes on and wait for the display to stop changing. Like any other thermometer, since temperature taking is a function of technique, mouth formation, and mouth temperature stabilization, it takes approximately 2 minutes before a reading is obtained in this mode. If the probe tip is warmer than 90° when the thermometer is turned on, it automatically goes into the extended reading mode.

5. Record the temperature, then depress the pushbutton again and it will return to the up position, turning off the thermometer. Temperature is erased and thermometer is reset, ready for the next reading.

APPENDIX C

STATEMENT MADE TO PARTICIPANTS

For the next two days, beginning tomorrow morning, I will be taking your temperature six times a day, at 10:00 a.m., 2:00 p.m., 4:00 p.m., 6:00 p.m., 8:00 p.m., and 10:00 p.m. I will come to your room to take your temperature between 15 minutes before the hour and 15 minutes after the hour. For example I will be here to take your 10 a.m. temperature some time between 9:45 a.m. and 10:15 a.m. If you would try to be in your room at those times I would appreciate it. Also, will you please avoid taking food or fluids 15 to 20 minutes before I take your temperature. Your meals should be completed before I come around so I trust it won't be too inconvenient. The extra temperatures that I am taking are not because of your condition, but part of a study to help nurses to know when temperature measurement would be most valuable. This will only last two days. I thank you so much for your cooperation.

APPENDIX D

NOTICE TO NURSING PERSONNEL POSTED ON UNIT

ATTENTION ALL NURSING PERSONNEL:

The patients on your unit, listed below, are part of a research study involving oral temperature measurements. If possible, please try to avoid giving patients food or fluids for 20 minutes before their temperature is to be taken by me. I will be taking temperatures between 15 minutes before the hour and 15 minutes after the hour at the following times: 10 a.m., 2 p.m., 4 p.m., 6 p.m., 8 p.m., and 10 p.m. As soon as I have taken the patient's temperature they are free to eat and drink. All meals should be completed before I take the temperatures, including supper. Please encourage patients to be in their room at those times. The study will only last two days on each patient. Thank you so much for your help!

Phyllis McElmurry, R.N.
Graduate Student

Patients	Room #
1.	
2.	
3.	
4.	
5.	

APPENDIX E

DATA SHEET

Room	Name	Age	Day	Oral Temperatures							Nap/Alert	Menopause or	Arising Time	Bedtime	Diagnosis	Medications
				10 a.m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Peak						
			1													
			2													
			Mean													
			1													
			2													
			Mean													
			1													
			2													
			Mean													
			1													
			2													
			Mean													
			1													
			2													
			Mean													
			1													
			2													
			Mean													

APPENDIX F

TEMPERATURES OF SIXTY-TWO FEMALE
HOSPITALIZED SUBJECTS

Subject	Age	Day	HOURS (PACIFIC STANDARD TIME) All Values in Degrees Fahrenheit					
			10:00	14:00	16:00	18:00	20:00	22:00
* 1	32	1	97.4	98.4	98.6	98.6	97.4	97.6
		2	97.8	97.4	97.8	98.8	98.0	97.4
		Mean	97.6	97.9	98.2	98.7	97.7	97.5
* 2	35	1	98.2	98.4	97.6	97.6	98.6	98.0
		2	97.8	98.4	98.6	98.0	98.4	98.2
		Mean	98.0	98.4	98.1	97.8	98.5	98.1
3	55	1	99.2	99.4	98.6	98.2	98.2	99.4
		2	99.0	99.6	98.8	98.4	98.4	98.2
		Mean	99.1	99.5	98.7	98.3	98.3	98.8
4	49	1	96.6	96.4	98.0	98.2	98.6	97.8
		2	98.4	98.0	98.0	98.8	97.8	97.4
		Mean	97.5	97.2	98.0	98.5	98.2	97.6
# 5	48	1	97.6	98.6	98.4	98.6	98.0	98.4
		2	97.6	97.6	98.0	98.8	98.8	97.6
		Mean	97.6	98.1	98.2	98.7	98.4	98.0
# 6	34	1	97.4	98.0	99.2	98.6	98.4	97.0
		2	97.4	97.6	98.4	97.8	98.6	99.2
		Mean	97.4	97.8	98.8	98.2	98.5	98.1
* 7	39	1	98.6	100.0	99.8	100.2	99.4	99.0
		2	98.0	98.6	99.0	99.0	98.8	98.2
		Mean	98.3	99.3	99.4	99.6	99.1	98.6
# 8	45	1	97.6	98.4	98.6	98.8	98.2	97.0
		2	97.6	98.4	98.6	99.2	99.0	98.8
		Mean	97.6	98.4	98.6	99.0	98.6	97.9
* 9	21	1	98.4	98.8	99.0	98.6	98.4	98.0
		2	97.4	96.8	97.4	96.4	97.8	97.0
		Mean	97.9	97.8	98.2	97.5	98.1	97.5
*10	24	1	98.2	98.4	99.4	99.6	99.4	100.0
		2	98.4	98.6	98.8	98.0	98.2	97.8
		Mean	98.3	98.5	99.1	98.8	98.8	98.9
*11	53	1	98.0	98.2	98.0	98.2	98.8	98.0
		2	98.2	98.2	98.0	98.4	98.4	97.8
		Mean	98.1	98.2	98.0	98.3	98.6	97.9

TEMPERATURES (continued)

Subject	Age	Day	HOURS (PACIFIC STANDARD TIME) All Values in Degrees Fahrenheit 10:00	14:00	16:00	18:00	20:00	22:00
12	73	1	98.4	98.4	99.2	98.6	99.2	99.0
		2	98.2	98.8	98.8	98.6	99.0	98.4
		Mean	98.3	98.6	99.0	98.6	99.1	98.7
13	71	1	98.6	99.2	98.2	98.8	99.2	98.8
		2	98.6	99.0	98.8	98.6	99.0	98.4
		Mean	98.6	99.1	98.5	98.7	99.1	98.6
14	81	1	99.6	100.6	100.8	100.4	100.6	98.2
		2	100.4	100.4	100.4	100.2	100.0	99.2
		Mean	100.0	100.5	100.6	100.3	100.3	98.7
15	79	1	98.0	98.0	98.4	99.0	98.8	98.8
		2	99.0	99.0	98.8	98.8	99.2	98.6
		Mean	98.5	98.5	98.6	98.9	99.0	98.7
*16	30	1	98.6	99.4	98.6	99.8	99.8	98.8
		2	99.6	100.2	99.2	99.6	98.6	98.0
		Mean	99.1	99.8	98.9	99.7	99.2	98.4
17	83	1	98.0	98.0	97.6	98.0	98.4	97.0
		2	97.8	97.4	97.6	97.4	97.0	97.4
		Mean	97.9	97.7	97.6	97.7	97.7	97.2
18	49	1	97.8	98.0	98.2	97.8	97.4	98.6
		2	97.6	97.2	97.4	97.6	97.8	98.2
		Mean	97.7	97.6	97.8	97.7	97.6	98.4
19	71	1	98.6	98.0	98.2	97.8	98.2	98.6
		2	98.4	98.2	98.0	98.6	98.8	99.4
		Mean	98.5	98.1	98.1	98.2	98.5	99.0
20	77	1	97.8	98.4	98.0	98.2	98.6	98.0
		2	98.4	97.8	97.8	97.6	97.8	98.0
		Mean	98.1	98.1	97.9	97.9	98.2	98.0
21	68	1	97.4	97.4	97.4	98.4	97.4	97.4
		2	97.2	94.4	96.4	95.6	97.2	97.6
		Mean	97.3	95.9	96.9	97.0	97.3	97.5
22	50	1	98.0	98.8	99.4	99.6	100.0	99.2
		2	98.0	99.0	99.0	98.4	99.0	97.8
		Mean	98.0	98.9	99.2	99.0	99.5	98.5

TEMPERATURES (continued)

Subject	Age	Day	HOURS (PACIFIC STANDARD TIME) All Values in Degrees Fahrenheit 10:00	14:00	16:00	18:00	20:00	22:00
23	75	1	99.0	99.6	99.6	100.2	99.6	98.8
		2	99.0	99.6	99.8	99.8	99.6	99.4
		Mean	99.0	99.6	99.7	100.0	99.6	99.1
24	55	1	98.6	98.4	98.2	99.0	98.6	98.4
		2	98.2	98.4	99.0	99.0	98.2	97.6
		Mean	98.4	98.4	98.6	99.0	98.4	98.0
25	72	1	98.2	98.6	98.6	99.2	99.6	99.6
		2	98.4	98.8	98.8	97.8	97.6	98.4
		Mean	98.3	98.7	98.7	98.5	98.6	99.0
26	74	1	97.6	98.4	98.4	98.0	97.8	97.0
		2	96.8	98.4	98.4	97.0	96.4	96.4
		Mean	97.2	98.4	98.4	97.5	97.1	96.7
27	76	1	98.4	98.8	99.2	98.4	99.0	97.6
		2	98.4	98.0	98.6	98.2	97.8	97.4
		Mean	98.4	98.4	98.9	98.3	98.4	97.5
28	69	1	98.0	98.4	98.6	98.8	99.2	98.6
		2	98.2	99.2	99.2	99.4	99.2	99.4
		Mean	98.1	98.8	98.9	99.1	99.2	99.0
29	72	1	97.8	98.4	98.6	98.8	99.2	99.0
		2	98.4	98.0	98.2	98.4	99.0	98.2
		Mean	98.1	98.2	98.4	98.6	99.1	98.6
30	88	1	98.6	99.4	99.8	99.4	99.6	99.6
		2	98.6	99.2	99.4	99.6	99.8	99.8
		Mean	98.6	99.3	99.6	99.5	99.7	99.7
31	53	1	97.6	98.6	98.6	98.8	99.4	98.6
		2	98.8	98.8	99.2	99.8	99.6	98.8
		Mean	98.2	98.7	98.9	99.3	99.5	98.7
32	75	1	98.8	98.6	98.2	99.0	98.6	99.0
		2	97.8	98.0	98.6	99.2	98.8	99.2
		Mean	98.3	98.3	98.4	99.1	98.7	99.1
33	82	1	99.0	99.6	99.4	99.6	99.0	98.6
		2	99.2	99.4	99.2	99.6	99.2	98.6
		Mean	99.1	99.5	99.3	99.6	99.1	98.6

TEMPERATURES (continued)

Subject	Age	Day	HOURS (PACIFIC STANDARD TIME) All Values in Degrees Fahrenheit 10:00	14:00	16:00	18:00	20:00	22:00
34	60	1	98.2	99.0	99.6	100.0	100.0	99.8
		2	98.6	99.2	98.6	99.0	99.2	100.0
		Mean	98.4	99.1	99.1	99.5	99.6	99.9
#35	40	1	97.6	98.0	97.8	98.6	98.2	97.8
		2	97.4	97.6	98.0	97.8	97.8	97.4
		Mean	97.5	97.8	97.9	98.2	98.0	97.6
*36	36	1	97.8	99.0	99.0	99.4	99.2	97.2
		2	98.6	99.2	98.2	99.6	98.2	97.2
		Mean	98.2	99.1	98.6	99.5	98.7	97.2
37	81	1	97.8	97.4	97.6	98.0	97.8	97.6
		2	96.8	96.0	97.4	97.8	97.4	96.8
		Mean	97.3	96.7	97.5	97.9	97.6	97.2
38	37	1	97.8	98.0	98.4	98.2	99.6	98.4
		2	96.4	98.6	97.8	97.2	99.0	97.2
		Mean	97.1	98.3	98.1	97.7	99.3	97.8
39	52	1	100.0	99.0	99.4	99.0	100.6	100.2
		2	98.4	99.2	99.8	99.4	98.0	99.4
		Mean	99.2	99.1	99.6	99.2	99.3	99.8
40	52	1	97.6	97.4	98.4	98.8	99.6	98.2
		2	97.2	98.8	99.2	98.6	98.2	99.4
		Mean	97.4	98.1	98.8	98.7	98.9	98.8
41	83	1	97.6	98.4	99.4	98.8	98.8	99.4
		2	98.2	98.8	98.0	98.4	98.6	99.2
		Mean	97.9	98.6	98.7	98.6	98.7	99.3
42	74	1	98.0	97.6	97.6	97.0	97.8	97.4
		2	97.0	96.6	97.8	97.8	97.6	97.4
		Mean	97.5	97.1	97.7	97.4	97.7	97.4
43	74	1	97.8	98.2	99.4	99.4	99.0	98.4
		2	98.0	98.4	98.8	99.2	99.2	98.8
		Mean	97.9	98.3	99.1	99.3	99.1	98.6
*44	42	1	98.8	98.6	98.2	99.2	98.4	99.0
		2	98.4	97.6	98.4	97.2	98.8	98.8
		Mean	98.6	98.1	98.3	98.2	98.6	98.9

TEMPERATURES (continued)

Subject	Age	Day	HOURS (PACIFIC STANDARD TIME) All Values in Degrees Fahrenheit 10:00	14:00	16:00	18:00	20:00	22:00
45	59	1	98.8	99.6	98.8	99.8	99.2	99.0
		2	98.8	97.6	99.2	99.8	98.2	98.0
		Mean	98.8	98.6	99.0	99.8	98.7	98.5
46	81	1	96.2	96.4	97.8	98.2	97.6	97.0
		2	96.8	97.4	98.6	98.2	97.8	98.0
		Mean	96.5	96.9	98.2	98.2	97.7	97.5
47	62	1	98.2	98.4	98.2	98.2	97.2	97.6
		2	97.4	97.6	98.2	97.8	97.4	96.8
		Mean	97.8	98.0	98.2	98.0	97.3	97.2
48	69	1	98.2	98.0	98.0	98.2	98.0	97.8
		2	97.6	98.4	98.6	98.0	98.0	97.6
		Mean	97.9	98.2	98.3	98.1	98.0	97.7
49	48	1	98.6	97.6	97.8	99.6	98.4	97.6
		2	98.6	98.4	97.6	98.4	98.4	97.4
		Mean	98.6	98.0	97.7	99.0	98.4	97.5
50	90	1	97.6	98.0	98.4	98.6	97.0	97.0
		2	97.0	96.6	97.6	98.0	98.0	98.2
		Mean	97.3	97.3	98.0	98.3	97.5	97.6
51	81	1	97.8	97.4	98.6	98.6	98.8	97.8
		2	97.0	97.4	98.0	98.2	98.8	97.0
		Mean	97.4	97.4	98.3	98.4	98.8	97.4
52	86	1	98.0	98.0	98.4	98.8	98.6	98.4
		2	97.0	98.0	98.0	99.0	98.0	98.0
		Mean	97.5	98.0	98.2	98.9	98.3	98.2
53	84	1	99.4	98.8	99.6	100.0	100.6	99.6
		2	98.4	98.2	99.4	99.8	100.4	99.4
		Mean	98.9	98.5	99.5	99.9	100.5	99.5
54	80	1	97.4	97.8	98.6	98.0	98.8	98.0
		2	98.0	98.0	97.8	97.4	97.8	98.2
		Mean	97.7	97.9	98.2	97.7	98.3	98.1
55	65	1	97.6	97.0	97.8	97.4	97.4	97.4
		2	98.8	98.6	98.0	97.8	98.2	96.8
		Mean	98.2	97.8	97.9	97.6	97.8	97.1

TEMPERATURES (continued)

Subject	Age	Day	HOURS (PACIFIC STANDARD TIME) All Values in Degrees Fahrenheit 10:00	14:00	16:00	18:00	20:00	22:00
56	69	1	98.4	98.4	98.2	98.8	98.6	97.4
		2	98.2	97.8	98.2	98.2	98.2	97.8
		Mean	98.3	98.1	98.2	98.5	98.4	97.6
57	56	1	98.0	98.2	98.0	98.0	98.0	97.4
		2	97.6	97.6	99.0	98.4	97.4	97.6
		Mean	97.8	97.9	98.5	98.2	97.7	97.5
58	65	1	98.0	97.8	97.6	96.8	97.0	97.0
		2	96.8	96.5	96.4	96.6	97.2	97.2
		Mean	97.4	97.2	97.0	96.7	97.1	97.1
*59	23	1	99.0	98.4	98.6	98.6	98.2	98.2
		2	99.0	98.8	99.0	99.0	98.8	98.6
		Mean	99.0	98.6	98.8	98.8	98.5	98.4
60	72	1	98.8	99.2	99.4	99.4	100.0	99.4
		2	97.6	98.0	98.0	97.6	98.2	97.8
		Mean	98.2	98.6	98.7	98.5	99.1	98.6
*61	26	1	98.6	98.2	99.2	98.8	98.8	98.2
		2	98.8	98.8	100.4	99.0	98.8	98.4
		Mean	98.7	98.5	99.8	98.9	98.8	98.3
62	71	1	99.0	97.8	98.4	98.8	98.6	97.4
		2	98.2	98.2	98.2	98.0	98.0	97.6
		Mean	98.6	98.0	98.3	98.4	98.3	97.5

* Premenopausal
# Ovariectomized