erect position does not possess any of its theoretical advantages and (2) it is impracticable as long as a bed-rest is being used to maintain the position.

It is, however, suggested that a further study of a larger series of cases with the use of cardiac or surgical beds may yield more precise information.

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THERMAL CHANGES IN THE NORMAL MENSTRUAL CYCLE

BY

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It is almost a century since the first successful attempt to correlate changes in basal temperature with events in the menstrual cycle was made (Squire, 1868). Since that time there have been a large number of contributions to the literature, and good historical reviews have been made by Barton (1940), Tompkins (1944), and Palmer (1949). Important among the contributions was that of van de Velde (1928), who indicated that the higher level of temperature which obtains in the later part of the menstrual cycle is due to the secretion of progesterone by the corpus luteum. Vollmann (1941) showed that the time from the beginning of the higher level of temperature to the onset of menstruation is independent of the length of the cycle. Finally, various authors (Martin, 1943 ; Buxton and Engle, 1950 ; Garcia and Rock, 1958) found that the change in the temperature level coincided with the appearance of the secretory phase in edometrial biopsies. The cumulative effect of this evidence has been to establish that the change in the level temperature is an indication that ovulation has occurred.

Despite the many studies which have appeared, we still lack knowledge of the parameters of the temperature changes which accompany the normal menstrual cycle. The large series of Halbrecht (1945), containing 271 cycles, and of Siegler and Siegler (1951), with 1,012 cycles, were composed of patients who were being investigated for sterility ; and the series of Benjamin (1960), with 2,000 cycles, contained many such patients. The present study concerns only healthy fertile women, and was undertaken in order to establish what changes of temperature occur during the normal menstrual cycle.

Results

The series comprises 155 consecutive healthy women who adopted the thermal method of estimating the infertile period in order to regulate the size of their family. All were known to be fertile, or have subsequently proved themselves to be so. The patients come from all social classes, and no selection was exercised. The temperature was recorded rectally with an ordinary clinical thermometer by the patient as soon as she woke in the morning, and before she left her bed or undertook any activity. The temperature was recorded by the patient on a standard chart which was supplied to her.

During the period of study the patients provided temperature charts of 1,134 cycles. The distribution of the number of cycles during which the temperature was recorded by each patient is given in Table I. The frequency distribution of the lengths of the menstrual cycles in this group is given in Fig. 1 which shows a mode of 28 days, though the difference in the number of 26-, 27-, and 28-day cycles is small. There were 532 cycles of less than 28 days, and 438 cycles of more than 28 days, though the greater number of cycles shorter than 28 days is largely accounted for by the high incidence of 26- and 27-day cycles. If the 26-, 27-, and 28-day cycles are grouped together as a common mode, then there are only 213 cycles of shorter duration and 438 longer cycles.

TABLE I.—*Distribution of Number of Cycles Contributed by Each Person*

No. of cycles ..	1–5	6–10	11–15	16–20	21–25	26–30	31–35
,, ,, persons	86	26	23	11	5	2	2

The number of cycles in which a clear biphasic temperature graph was obtained is given in Table II. The number of graphs (16) which could not be interpreted because of technical errors on the part of the patient constituted only 1.4% of the series, indicating that to keep a record of the basal temperature is well within the competence of the average patient. This confirms the experience of Benjamin (1960), who found 0.4% of the charts produced were uninterpretable, though he had found that 2% of patients persistently failed to produce records. In the present series all the patients were eventually able to produce reliable records.

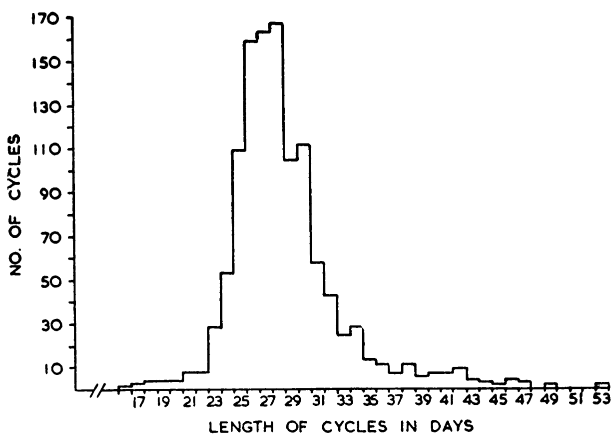

FIG. 1.—Histogram of distribution cycle lengths in 1,134 cycles

TABLE II

Cycles showing ovulatory rise in temperature ..	1,088
Anovulatory cycles	20
Record upset by illness or surgery	10
Technically inadequate record	16
	1,134

A monophasic graph, which indicates an anovulatory cycle, was seen in only 1.7% of the cycles, as compared with 29% in the series of Siegler and Siegler (1951) and 12.2% in that of Halbrecht (1945), but this difference merely reflects the fact that their series were composed of infertile women.

The change of the temperature from the lower to the higher level can occur in one of three ways: as an acute rise, as a slow gradual rise, and as a step-like rise. The criterion for an acute rise was an elevation of 0.4° F. between two consecutive days. These three kinds of rise are illustrated in Fig. 2. The incidence of each type of rise is shown in Table III.

In the case of the slow rise a variable number of days may elapse between the commencement of the rise

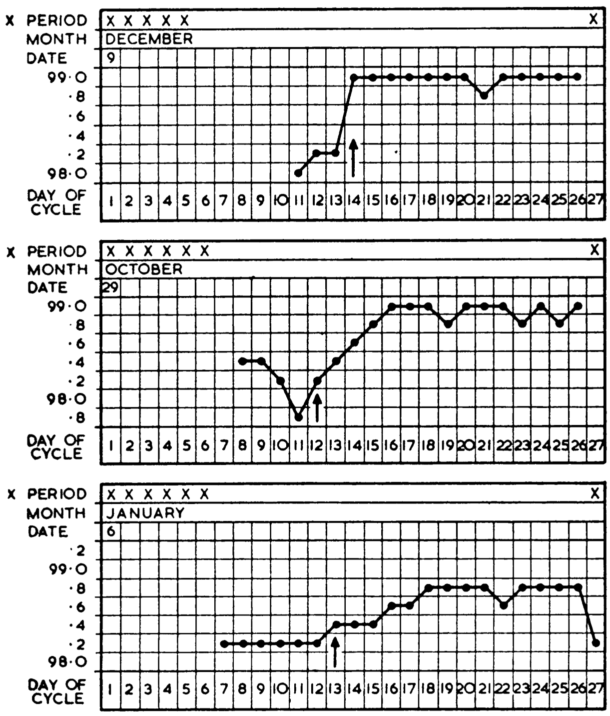

FIG. 2.—Types of ovulatory thermal rise from above downwards, (a) acute, (b) slow, and (c) step-like. Arrows explained in text.

TABLE III.—*Types of Temperature Rise*

Acute rise	0·4° F.	460	
	0·6° F.	304	.. 899
	0·8° F.	101	
	1° F.	34	
Slow steady rise	.. ..		160
Step-like rise	.. ..		29
			1,088

TABLE IV.—*Duration of Slow Rise in Days*

No. of days ..	3	4	5	6	7	8	9	10
,, ,, cycles ..	57	50	29	11	6	4	1	2

of temperature and the day on which the higher plateau is reached. The number of days taken in the present series is given in Table IV and varies from 3 to 10, with a great preponderance of three or four days. This is similar to the finding of Siegler and Siegler (1951).

Stress is often laid upon the occurrence of a "dip" before the rise of temperature as being a more precise indication of the time of ovulation. This dip was observed in 112 charts (10%) of the series. Halbrecht (1945) observed such a dip in 21% of 238 biphasic charts from his series of sterile women.

The time from the change of temperature level to the onset of the next menstrual period has been variously named the second phase, the luteal phase, and the post-ovulatory phase. The last of these terms is used here, though it is appreciated that the temperature shift may not indicate precisely the moment of ovulation. The duration of the post-ovulatory phase was measured either from the first temperature at the higher level in those charts showing an acute rise, or from the first temperature up the slope in the slow and step-like rises. These points are marked by arrows in Fig. 2. The frequency distribution of post-ovulatory phases of various lengths is shown in Fig. 3. This shows a mode of 13 days with 67% falling within the limits of 11 to 14 days. Especially noteworthy is the considerable number of post-ovulatory phases (17.6%) of less than 11 days' duration. This is, however, much less than the

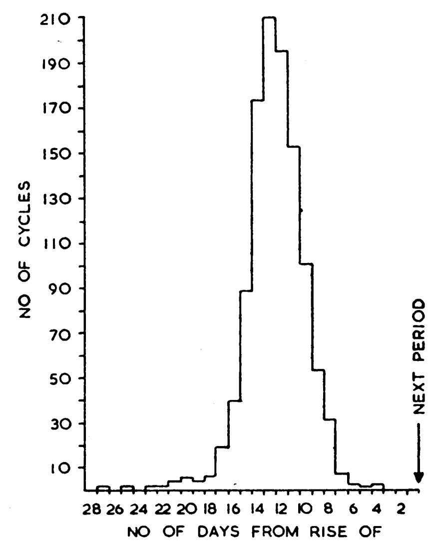

FIG. 3.—Histogram of distribution of lengths of post-ovulatory phase in 1,088 cycles.

TABLE V.—*Distribution of Length of Post-ovulatory Phase in Cycles of Various Lengths.*

Length of Post-ovulatory Phase in Days	Length of Cycle in Days: Up to 24		25–26		27–28		29–30		31–32		33+		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
<10	23	24	24	9	28	9	13	6	2	2	4	3	94	9
10	14	15	29	11	32	10	11	5	6	6	6	5	98	9
11	14	15	38	15	46	14	31	15	11	12	14	12	154	14
12	19	20	57	22	51	16	33	16	17	18	15	13	192	17
13	15	15	44	17	64	20	39	19	22	23	26	22	210	19
14	5	5	39	15	55	17	33	16	17	17	24	21	173	16
15	5	5	17	7	26	8	22	11	9	9	9	8	88	8
16	1	1	7	3	9	3	12	6	4	4	6	5	39	4
>16	0	0	2	0	7	2	10	5	8	8	13	11	40	4
Total	96	100	257	99	318	99	204	99	96	99	117	100	1,088	100
Mean post-ovulatory period	11·3		12·2		12·4		12·9		13·2		13·2			

43% found by Siegler and Siegler (1951) in sterile women.

The relationship between the length of the post-ovulatory phase and that of the whole cycle was next examined, and is shown in Table V. Despite the variability in the length of the post-ovulatory phase it is clearly much more stable than is the pre-ovulatory phase, which varies directly with the length of the cycle. The post-ovulatory phase, on the other hand, is of a relatively fixed duration, but shows some relationship to the length of the cycle. This is shown by the progressive increase in its mean value as the cycle length increases (Table V).

In order to see whether the scatter in the lengths of the post-ovulatory phase was due to a variation between patients or to variation within a patient, the data from the seven patients who had contributed the greatest number of cycles was examined (Table VI). These show a considerable scatter within each patient, though the mean length of the post-ovulatory phase clearly varies significantly from one patient to another.

TABLE VI.—*Distribution of Length of Post-ovulatory Phase in 7 Patients who Contributed Most Cycles to the Series*

Length of Post-ovulatory Phase in Days	Frequency of Post-ovulatory Period (Percentages in Parentheses)						
	Patient						
	1	2	3	4	5	6	7
8			2 (7)	2 (8)			
9	4 (12)		0 (0)	1 (4)			
10	7 (21)		0 (0)	1 (4)	2 (9)		2 (10)
11	5 (15)	2 (7)	16 (55)	3 (12)	1 (5)	5 (21)	2 (10)
12	6 (18)	5 (17)	5 (17)	7 (27)	9 (41)	2 (8)	3 (14)
13	0 (0)	8 (27)	2 (7)	5 (19)	5 (23)	6 (25)	2 (10)
14	7 (21)	9 (30)	1 (4)	5 (19)	2 (9)	6 (25)	7 (33)
15	0 (0)	3 (10)	2 (7)	2 (8)	3 (14)	2 (8)	4 (19)
16	3 (9)	1 (3)				2 (8)	0 (0)
17	1 (3)	2 (7)				1 (4)	0 (0)
18							1 (5)
25			1 (3)				
Total no. of cycles	33	30	29	26	22	24	21

Discussion

The important feature of the present data is that they were obtained from an unselected series of healthy, fertile women. Apart from a report by Geller (1961), previous information about temperature changes in the menstrual cycle has been based on either anecdotal evidence or on groups of infertile women. Evidence of this kind, though not without value, makes it difficult to know what are the limits of normality and when a particular phenomenon which may be encountered in the individual patient must be considered pathological. Geller (1961) has presented a frequency curve for the post-ovulatory phase in 590 cases, but does not indicate the type of case he was studying.

The most striking phenomenon in the present series was the considerable number of cycles in which the post-ovulatory phase as measured by the temperature was less than 11 days. There are two possible explanations for this. The first is that the rise of temperature was delayed for some time after ovulation, the true post-ovulatory phase being made longer than that indicated by the temperature chart. Buxton and Engle (1950) operated on 18 patients on the day of their temperature rise and found two in which the corpus luteum apeared to be 48 hours old and two in which it appeared to be 72 hours old. They stress, however, that it is difficult to tell the age of a corpus luteum even on microscopy, which they carried out in every case. On the other hand, when evidence for ovulation has been sought simultaneously from the temperature chart, endometrial biopsy, and vaginal smears, the results have been concordant (Garcia and Rock, 1958). In their series of cases ovulation was occurring about 12 days before the onset of the next menstruation; there does not appear to be any similar study of cases in which the rise of temperature was occurring late in the cycle.

The second explanation for the short post-ovulatory phase is that the orthodox view that ovulation occurs 12 to 16 days before the onset of the next menstruation, though true of the majority, is not universally applicable, and that there are cases in which ovulation occurs late in the cycle. The practical implications of this are obvious. When it is desired to know the time of ovulation, either to promote or to avoid conception, it is insufficient to rely on a calculation based on the expected date of the next menstrual period; temperature recordings must be made in order to ascertain when ovulation is occurring. Moreover, these recordings must be continued during each cycle for which the information is required, for there is a considerable variation from cycle to cycle in the same subject.

Although the post-ovulatory phase varies in length, it is of relatively fixed duration as compared with the pre-ovulatory phase. Long cycles gain their length not by an increase in the post-ovulatory phase but in the pre-ovulatory phase. Yet among the variations in the length of the post-ovulatory phase a pattern can be discerned. There is a slight tendency for the length of the post-ovulatory phase to increase with increasing length of the cycles. This increase is small as compared with that of the pre-ovulatory phase, amounting to barely two days when the cycle length is increased by nine days. Nevertheless, the tendency is there, and again indicates the need to record the basal temperature rather than to rely on estimated times of ovulation.

Summary

The basal temperature has been recorded through 1,134 menstrual cycles by 155 healthy fertile women. Twenty cycles were anovulatory, 10 upset by illness, 16 inadequately recorded, and 1,088 showed the rise of temperature which is associated with ovulation. The commonest time for the rise was 13 days before the onset of the next menstruation, but there was a wide variation. The time from the rise to the next menstruation increased slightly with increasing length of the cycle.

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