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Menstrual bleeding, cycle length, and follicular and luteal phase lengths in women without known subfertility: A pooled analysis of three cohorts

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Abstract

Background: There is variability between women for days of menstrual bleeding, cycle lengths, follicular phase lengths, and luteal phase lengths, related to age and parity.

Objective: To describe total cycle length; anovulatory cycles; follicular and luteal phase lengths; and days and intensity of menstrual and non-menstrual bleeding in women without known subfertility over the course of 1 year.

Methods: 581 women (3,324 cycles) with no known subfertility (18–40 years of age) were followed for up to 1 year. Women recorded vaginal bleeding and mucus discharge daily. We used the peak day of cervical mucus as the estimated day of ovulation and the last day of the follicular phase. We used generalised linear mixed models stratified by age and parity to describe menstrual cycle parameters.

Results: The majority of women were <30 years of age (74.5%), non-Hispanic White (88.6%), and nulliparous (70.4%). The mean menses length was 6.2 (1.5) days, median 6; cycle length 30.3 (6.7) days, median 29; follicular phase length 18.5 (6.5) days, median 17; and luteal phase length 11.7 (2.8) days, median 12. Nulliparous women aged ≥30 years vs nulliparous women aged <30 had shorter cycles (29.2 days, 95% confidence interval (CI) 27.8, 30.7 vs 31.5 days, 95% CI 30.8, 32.2) and shorter follicular phases (17.6 days, 95% CI 16.2, 18.9 vs 19.6 days, 95% CI 18.9, 20.2). Among all women, within-woman differences between the longest and shortest menses length >3 days, total cycle length >7 days, follicular phase >7 days, and luteal phase >3 days were found in 11.6%, 43.0%, 41.7%, and 58.8% of women, respectively.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

CONFLICT OF INTEREST

None.

Conclusions: Our findings confirm variability between women of menstrual cycle parameters related to age and parity, and also highlight within-woman variability in the follicular and luteal phases.

Keywords

follicular phase; luteal phase; menstrual cycle; menstruation; ovulation; peak day

1 | BACKGROUND

Menstrual cycles are measurable vital signs of women's reproductive health¹ and are repeated up to about 500 times within a healthy woman's 35- to 40-year reproductive lifespan, from menarche to menopause. Menstrual cycles are indicative of not only women's reproductive health but also functioning of other body organs and systems. For example, bleeding problems and menstrual irregularities are common in hypothyroid women.² Women's reproductive dysfunction has been linked to long-term risk of developing chronic diseases including osteoporosis, some types of cancer, and cardiovascular diseases.^{3,4} Thus, women, clinicians, and researchers need to have a solid understanding of menstrual cycle characteristics and their normal spectrum and variability¹ at any given age. Age and parity are two factors known to influence menstrual cycle characteristics.^{5,6} There are few recent studies using complete detailed daily diary data of sufficient duration to assess normal within-woman variability of menstrual characteristics, using appropriate statistical methods to account for different numbers of cycles per woman.⁷⁻⁹

The objective of this study was to describe total cycle length; anovulatory cycles; follicular and luteal phase lengths; and days and intensity of menstrual and non-menstrual bleeding, while assessing variability between-women and within-woman variability, in relation to age and parity. We analysed data from three previous cohort studies of women without any known subfertility and who were not currently taking any exogenous hormonal treatment, followed for up to 1 year.

2 | METHODS

This cohort study is a secondary data analysis of three cohorts of heterosexually active women who received instruction in the Creighton Model FertilityCare System (CrM) through centres across the United States and Canada. The CrM has standardised protocols for teaching women how to observe, record, and interpret daily vaginal discharge from bleeding and cervical fluid on a daily diary, called a CrM chart, and to use these standardised observations to identify the estimated time of ovulation and days when intercourse is likely to result in pregnancy.⁹⁻¹⁵ The cohorts included: "Creighton Model Effectiveness, Intentions, and Behaviours Assessment" (CEIBA) (2009–2013), a prospective cohort of women without known subfertility, aimed to evaluate and classify pregnancy rates and pregnancy intentions during use of the CrM¹⁶; "Creighton Model MultiCenter Fecundability Study" (CMFS) (1990–1996), a retrospective cohort of presumably fertile and subfertile women using CrM, aimed to assess the relationship between vulvar mucus observations and the day and cycle-specific probabilities of conception¹⁷; and "Time to

Pregnancy in Normal Fertility” (TTP) (2003–2006), a parallel-randomised trial, which aimed to assess the impact of CrM use on time to pregnancy in couples of proven fertility trying to conceive.¹³ From CEIBA, all participants (293 women); from CMFS, only data from the presumably fertile new users of CrM (309 women); and from TTP, only participants in the CrM intervention group (68 women) were included for this study (Table S1).

Each of the cohorts aimed to include heterosexually active couples with normal fecundity. Eligibility criteria were assessed by women’s responses to the CrM general intake form and/or a screening questionnaire. Eligibility requirements in the original studies included women, age 18–40 years old (upper limit of 35 years for TTP), not pregnant at entry, having regular menstrual bleeding, and not breast feeding (CMFS and TTP), or if breast feeding, not doing so exclusively (CEIBA). Recent users of oral contraceptives had to have at least one menstrual bleed (CEIBA) or two menstrual bleeds (TTP) since stopping the oral contraceptives; however, for CMFS there was no restriction for time since discontinuing oral contraceptives.^{9,18} All studies also required normal menstrual patterns since last use of depo-medroxy-progesterone acetate or a hormonal intra-uterine device. Women were excluded if they reported any history of infertility (on a yes/no question), surgeries that impair fertility (such as sterilisation). We also excluded women with history of polycystic ovarian syndrome, endometriosis, or thyroid disease (7.3%). We excluded cycles outside the time frame of each study (13.8%), cycles with incomplete information on the CrM chart (15.4%), and cycles subject to exogenous hormonal or other medications or unusual circumstances that may affect the natural physiology of menstrual cycles (2.2%). We also excluded cycles > 100 days (0.1%). Table S1 summarises the cycles excluded by each of the criteria. Participants contributed cycles for up to 1 year (CMFS and CEIBA), or 7 cycles (TTP). Earlier exit could occur due to withdrawal from study, loss to follow-up, pregnancy, or beginning hormonal contraception.^{13,16,17}

For two of the original studies (CMFS and CEIBA), women were required at entry to the study to be seeking to avoid pregnancy; however, they were able at any point during the study follow-up to seek pregnancy, without exiting the study; 26% and 42% conceived, respectively.^{16,17} For TTP, women were required at entry to the study to be intending to conceive; 78% conceived.¹³

Self-reported demographic information and reproductive, medical, and surgical history of women were obtained primarily from the CrM general intake form. Prospective assessment included daily observations recorded on the CrM charts for vaginal discharge at vulva (cervical mucus and bleeding).¹⁰ The CrM charts were on paper and were collected by CrM teachers or study staff at least every month during the first three months, and at least every 3 months following.

To assess the cycle phase lengths and bleeding characteristics, we used continuous measures, and we also defined cut-off points for each characteristic based on prior research, or clinical estimates (Table S2). Not all cycles could be used for all analyses. For example, only cycles with an estimated day of ovulation could be used to analyse length of the follicular phase, and only ovulatory cycles without conception could be used to analyse length of the luteal

phase (details in Table S3). For cycles with non-menstrual bleeding, we analysed the days of abnormal bleeding. In the event of conception, subsequent cycles from that woman were censored.

The first day of each menstrual cycle was identified by the woman in the CrM chart, and the cycle lasted until the day before the first day of the next menstrual cycle, or until pregnancy was confirmed for conception cycles. Women reported intensity of vaginal bleeding each day as heavy, moderate, light, very light, or brown or black bleeding. No specific guidelines or definitions were given to women for the codes of heavy, moderate, or light bleeding. For some analyses, we considered either very light red, brown or black bleeding as spotting. We also calculated an estimate of the intensity of menstrual flow over the first 6 days of the cycle, using a published index based on the bleeding codes.⁹

We used the peak day of cervical mucus as the estimated day of ovulation and the last day of the follicular phase. The peak day of cervical mucus has been shown to be a reliable indicator of the estimated day of ovulation (EDO), similar to urinary LH.^{19–22} In each cycle record, the peak day of cervical mucus was independently reviewed by at least two trained reviewers. In the case of conflict between the reviewers, the final determination was made by the principal investigator (JBS). We considered cycles without a plausible peak day of cervical mucus to be anovulatory. There were five CMFS and two CEIBA conception cycles (seven women) with unknown peak day. To impute these peak days, we used the same ovulation day of the first previous cycle available.²³ For one woman with only one cycle, we used the population median peak day.

2.1 | Statistical analysis

We used descriptive statistics to summarise each menstrual cycle characteristic. We used linear and generalised linear mixed models to assess menstrual cycle characteristics stratified by two key factors known to influence menstrual cycle function: age (<30 years vs ≥30 years) and parity (nulliparous vs parous).²⁴ We chose random intercept models to account for variation in baseline menstrual cycle characteristics in individual women and the correlation between cycles of the same woman. For within-woman variability in each of the phase length variables, we subtracted the shortest from the longest value for each woman with at least two charted cycles.

We conducted several sensitivity analyses: stratifying by a different age cut point (<35 years vs ≥35 years) to further examine older age; restricting data to the first three cycles to assess possible impact of unidentified subfecundity; excluding women who had used oral contraceptives within 60 days prior to the study to assess impact of their recent use; and stratifying by current partial breast feeding. All statistical analyses were performed using SAS software (9.4 – North Carolina).

2.2 | Ethics approval

All studies were approved by the University of Utah Institutional Review Board, as well as local site IRBs.

3 | RESULTS

There were 581 women, contributing 3324 menstrual cycles, with no known subfertility, followed for up to 1 year. The majority of women were <30 years of age (74.5%), with a mean age of 27.1 (4.2) years. The majority of women were nulligravid (66.3%) and nulliparous (70.4%). Fifty women (8.6%) had at least one prior obstetric or gynaecologic surgery; most of these had a prior Caesarean section (31 women, 5.3%). The demographic characteristics, and reproductive and medical history of participants are described further in Table 1 (overall cohort) and Table S4 (each of three cohorts).

The mean number of cycles per woman in the final dataset was 5.7 (3.7) cycles (min: 1, 25th: 2, 50th: 5, 75th: 9, max: 15). Seventy-two women had only one cycle. Conception occurred in 187 recorded cycles (5.6%) and 115 cycles (3.5%) was anovulatory. Some cycles (679; 20.4%) had streamlined data entry, which meant that information was available for cycle length, follicular and luteal phase length, but not for bleeding (Table S3).

The mean duration of menstrual flow was 6.2 (1.5) days, median 6 (Table 2). The proportion of cycles with any bleeding/spotting during the follicular phase (outside menses) was 10.0%, 95% confidence interval (CI) 8.8, 11.1 (Table S6), with a mean of 2.2 days of any bleeding/spotting (Table 3). The proportion of cycles with any bleeding/spotting during luteal phase was 7.9%, 95% CI 6.9, 9.0 (Table S6), with a mean of 2.5 days of any bleeding/spotting, 95% CI 2.1, 2.8 (Table 3). There was no difference between women in any of the bleeding parameters by age or parity (Tables 3,4; Tables S5-S6).

Among all cycles, 96.5% had a mucus peak day and were considered ovulatory. The proportion of ovulatory cycles among nulliparous women was lower than parous women, 95.9% vs 98.2% (risk ratio (RR) 0.98, 95% CI 0.96, 0.99). We did not find any difference in proportion of ovulatory cycles by age among nulliparous or parous women (Table S6).

Figure 1 displays the distribution of menses and cycle phase lengths. The mean cycle length was 30.3 (6.7) days, median 29 (Table 2). The proportion of short cycles (<23 days) and long cycles (>35 days) was 1.2%, 95% CI 0.8, 1.5, and 11.0%, 95% CI 9.9, 12.1, respectively (Table S6). Nulliparous women aged ≥30 compared to nulliparous women <30 had shorter cycle lengths (29.2 days, 95% CI 27.8, 30.7 vs 31.5 days, 95% CI 30.8, 32.2) (Table 3). From age 20 to over age 35, there was a gradual shortening of mean cycle length, from 31.7 days to 29.8 days (Table S7).

The mean follicular phase length was 18.5 (6.5) days, median 17 (Table 2). The proportion of cycles with short follicular phase (<10 days) and prolonged follicular phase (>21 days) was 0.8%, 95% CI 0.5, 1.1, and 18.3%, 95% CI 17.0, 19.6, respectively (Table S6). Compared with nulliparous women <30, nulliparous women ≥30 had shorter follicular phase (17.6 days, 95% CI 16.2, 18.9 vs 19.6 days, 95% CI 18.9, 20.2) (Table 3).

The mean luteal phase length was 11.7 (2.8) days, median 12 (Table 2). The proportion of cycles with a short luteal phase (<10 days), and a prolonged luteal phase (>16 days) was 18.1%, 95% CI 16.7, 19.5, and 3.9%, 95% CI 3.2, 4.6, respectively (Table S6). The luteal

phase length was shorter for parous compared with nulliparous women (11.4 days, 95% CI 11.0, 11.7 vs 11.8 days, 95% CI 11.6, 12.0) (Table S5).

Within-woman differences between the longest and shortest menses length >3 days, total cycle length >7 days, follicular phase >7 days, and luteal phase >3 days were found in 11.6%, 43.0%, 41.7%, and 58.8% of women, respectively. There was more variability in length of luteal phase among nulliparous women ≥ 30 compared with nulliparous women <30 (RR 1.34, 95% CI 1.15, 1.57) (Table 4).

In sensitivity analyses, we found that nulliparous women over age 35 compared with nulliparous women ≤ 35 had slightly shorter follicular phases (17.3 vs 19.3 days) and slightly shorter cycles (28.9 vs 31.1 days). Women over age 35 were more likely to have >3 days variability in luteal phase length (76.2% vs 58.1%) (Table S8). In analyses restricted to the first three cycles, all results were very similar to the main analyses (Table S9). The mean cycle and follicular phase lengths were 0.3–0.6 days shorter in the different subgroups by parity and age after excluding women who had discontinued oral contraceptives within 60 days prior to the study, but other cycle characteristics were the same (Table S9). From the CEIBA study, 24 women (4.1%) were partially breast feeding. These women had shorter mean cycle length (29.6 vs 31.0 days), shorter follicular length (18.5 vs 19.1 days), and shorter luteal length (11.0 vs 11.7 days) (Table S10).

4 | COMMENT

4.1 | Principal findings

In this pooled analysis of three cohorts, we found substantial variability in total cycle, follicular and to a lesser extent, luteal phase lengths between and within eumenorrheic women over the course of 1 year. Menstrual bleeding days and bleeding intensity varied between women but were mostly consistent within women. There were few anovulatory cycles, but these were more common among nulliparous women. Among nulliparous women, older age was associated with shorter cycle lengths and shorter follicular phase lengths.

4.2 | Strengths of the study

Prospectively collected daily diaries among women selected to exclude subfertility are among major strengths of this study.⁴ Some prior studies have had a limited number of cycles or have not used the appropriate statistical methods to adjust for varying number of cycles for women.^{3,7,25} The CrM charting protocol identifies a marker of ovulation and systematically captures all vaginal discharge, including bleeding, for every day of the cycle.^{10–12}

4.3 | Limitations of the data

We cannot exclude the possibility of unknown subfertility or gynaecologic disorders among some of the women, such as undetected endometriosis or polycystic ovary syndrome; such women may have contributed more cycles. The generalised linear model adjusts for number

of cycles per woman. In a sensitivity analysis restricted to the first three cycles, there were very similar results (Table S9).

Women in these cohorts were geographically dispersed but relatively homogeneous with regard to race, ethnicity, income, and educational levels, which may limit generalisability of the findings. We did not have data on metabolic parameters, such as body mass index, and health behaviours such as physical activity. The original cohorts lacked specific guidelines for describing menstrual flow intensity, which means that the comparisons between women for intensity of bleeding should be interpreted cautiously.

Some of our women had discontinued oral contraceptives within the past 60 days (92 women, 15.8%). Recent use of oral contraception may delay ovulation and thus prolong follicular and cycle length.^{9,26,27} We found that exclusion of women who had recently discontinued oral contraceptives resulted in mean cycle and follicular phase lengths that were about a half day shorter (Table S9).

4.4 | Interpretation

Our findings join a growing body of work contradicting the idealised standard of a 28-day cycle with ovulation occurrence on about day 14 (with mid-luteal being about day 21), or the common belief of fixed post ovulatory luteal phase of 14 days.^{9,24,28–32} In the normal spectrum of women not on exogenous hormones, this idealised cycle is actually the small minority of cycles.^{32–34} In our study, the prevalence of estimated ovulation on day 14, and the length; D, Luteal phase length prevalence of luteal phase length of 14 days were 8.7% and 9.7%, respectively.

Recently published studies examined cycle phase lengths in women using apps that track the menstrual cycle. The day of ovulation was determined by urinary LH and/or basal body temperature. Among 98 903 users of Ovia Fertility, the median cycle length was 28 days, follicular phase 17 days, and luteal phase 11 days.³² Among 27 378 users of Kindara, median cycle length was 28, follicular phase 15, and luteal phase 13 days.³³ Among 28 483 users of Sympto, median cycle length was 28, follicular phase 16, and luteal phase 12 days.³³ Finally, among 124 648 women using Natural Cycles, the mean cycle length was 29.3 (SD 5.2), follicular length 16.9 (SD 5.3), luteal length 12.4 days (SD 2.4).³⁴ In each study, <50% of cycles had complete data, there were no data for parity, and only ovulatory cycles were analysed. Noting some differences in age distribution across the studies, these results for cycle phase range are in a similar range with our results for cycle phase lengths. Our cycle phase lengths are also concordant with prior research using CrM and the peak day of cervical mucus as the estimated day of ovulation and the last day of the follicular phase.²⁰

We found that within nulliparous women, there was a shorter cycle length (by more than 2 days) and shorter length of follicular phase (by 2 days) after age 30. Previous studies also showed that with increasing age, mean menstrual cycle length declines as a function of declining follicular phase length, with minimal change in luteal length.^{24,30,34}

The clinical significance of short luteal phases has been disputed, and different thresholds have been used to identify a luteal phase defect.^{8,35–38} For this reason, we examined cut

points for a short luteal phase of 8, 9, or 10 days (Table S6). In a study of women age 30 and over (68% <35 years), 18% of cycles were characterised by a luteal phase of 10 days (after removing the day of ovulation for comparison)³⁸; in our data with somewhat younger women, we found 18.1% of cycles with a luteal phase of <10 days.

Our results are in agreement with most previous studies that reported less absolute variability in the follicular phase compared to the luteal phase.^{34,39} Variability in luteal phase length is mainly attributed to the variable length of the early luteal phase, that is luteinisation process.³⁹

Within-woman cycle length variabilities, both very short and very long cycles, are greatest immediately after menarche and shortly before menopause,³ lasting 2–5 years per transition,³ in part due to a higher incidence of anovulatory cycles in these life phases.²⁴ In our study, the numbers of women <20 or >35 years of age were small, limiting our ability to assess the beginning and end of the reproductive life span. In the mid-reproductive age range, the existence of within-woman variability may reflect ovarian steroid hormones responses to behaviours such as physical activity, dietary intake, sleep variation, and stress as well as environmental factors.⁴⁰

Using the peak day of cervical mucus as the estimated day of ovulation, 3.5% of our study contributed cycles were anovulatory. According to Lynch et al, the prevalence of sporadic anovulatory cycles varied between 3.4% and 18.6% in the BioCycle study (2014), depending on the diagnostic criteria used, with many of them based on different thresholds of luteal progesterone.⁴¹ We did not assess progesterone levels. Our definition is based on the mucus peak, which has been found to be similar in sensitivity and timing to urine LH testing.^{19–22}

Differences in the definitions of menstrual and non-menstrual bleeding and their intensity limit comparisons with other studies for bleeding.³¹ Compared with the BioCycle study (2012), we found a longer median of menstrual flow (6 vs 5 days) among women with no known subfertility. We did not find any difference in length of menses and its intensity score by parity or age. This contrasts to Dasharathy et al, who reported that older, married, and parous women reported heavier bleeding.⁷

Given the wide spectrum of normal menstrual cycles' variability between women, and heterogeneity in reproductive potential of fertile women,^{3,28,31,39} setting strict thresholds for cycle phase lengths or bleeding patterns to distinguish abnormal or subfecund cycles from normal fecund cycles may be difficult.³⁹ Thus, the clinical implications for many of our findings are not fully clear. However, other research has indicated that cycles with short luteal phases may indicate temporarily reduced fecundability,^{35,38} and premenstrual spotting might correlate with undiagnosed endometriosis.⁴²

5 | CONCLUSIONS

This study adds to a growing body of work emphasising the need to recognise a wider variability in menstrual cycle lengths in clinical work and research. In particular, within-woman variability in cycle characteristics may be an important health indicator to assess in relation to the impact of behavioural, metabolic, and environmental factors. In addition,

future work should investigate cycle characteristics in women with various reproductive or gynaecologic pathologies. Menstrual cycles tracking apps have a potential to contribute much relevant data in the future, provided that sufficient attention is paid to selection and describing relevant clinical covariates.⁴³

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Synopsis

Research question

What are the menstrual cycle phase lengths of eumenorrheic women?

What's already known

There is more between women than within-woman variability for days of menstrual bleeding, cycle length, follicular phase length, and luteal phase length.

What this study adds

Over 1 year's observation of 581 women, nulliparous women aged ≥ 30 years vs <30 had shorter cycles (mean 29.2 vs 31.5 days), and shorter follicular phases including the estimated day of ovulation (17.6 vs 19.6 days). Between cycles, 11.6% of women had more than 3 days difference in days of menstrual bleeding, 43.0% had more than 7 days difference in cycle length, 41.7% more than 7 days difference in the follicular phase, and 58.8% more than 3 days difference in the luteal phase.

FIGURE 1.

Distribution of cycle phase lengths of all cycles of study population. A, Cycle length; B, Menstrual flow; C, Follicular phase length; D, Luteal phase length

TABLE 1

Demographic and reproductive characteristics, and medical history of study population; 581 women without known subfertility, 1990–2013^a

Total	No (%) 581
Demographic characteristics	
Age (y)	
<30	433 (74.5)
30	148 (25.5)
Missing	0 (0.0)
Mean (SD)	27.1 (4.2)
Min, Max	18, 40
25, 50, 75 percentile	24, 27, 30
Missing	0
Race and ethnicity	
White (non-Hispanic)	515 (88.6)
Hispanic/Latino	28 (4.8)
Other	33 (5.7)
Missing	5 (0.9)
Religion	
Catholic	422 (72.6)
Protestant	64 (11.0)
Latter-day Saints	45 (7.8)
Other	29 (5.0)
None	13 (2.2)
Missing	8 (1.4)
Marital status	
Single	50 (8.6)
Engaged	172 (29.6)
Married	351 (60.4)
Divorced/Widowed/Separated	3 (0.5)
Missing	5 (0.9)
Completed education	
High/Vocational/Technical school graduate or less	44 (7.6)
Some college	112 (19.3)
College graduate	418 (71.9)
Missing	7 (1.2)
Occupational status	
Professional	290 (49.9)
Technical/Skilled and Unskilled labourer	30 (5.2)
Clerical/Sales	66 (11.4)
Homemaker	81 (13.9)
Student	79 (13.6)

Total	No (%) 581
Other	26 (4.5)
Missing	9 (1.6)
Employed	
Yes	451 (77.6)
No	122 (21.0)
Missing	8 (1.4)
Federal poverty level, adjusted by year	
<150%	51 (8.8)
150%–200%	42 (7.2)
>200%	437 (75.2)
Missing	51 (8.8)
Reproductive history	
Age at first menstruation (y)	
10	21 (3.6)
11–14	483 (83.1)
15	68 (11.7)
Missing	9 (1.6)
Gravidity	
0	385 (66.3)
1	191 (32.9)
Missing	5 (0.9)
Age at first pregnancy (y)	
Never pregnant	385 (66.3)
19	16 (2.8)
20–24	85 (14.6)
25–29	74 (12.7)
30	16 (2.8)
Missing	5 (0.9)
Parity	
Nulliparous	409 (70.4)
Parous	166 (28.6)
Missing	6 (1.0)
Spontaneous abortions	
None	526 (90.5)
At least one	49 (8.4)
Missing	6 (1.0)
Stillbirths	
None	571 (98.3)
At least one	4 (0.7)
Missing	6 (1.0)
Self-reported nature of cycles	
Regular	377 (64.9)

Total	No (%) 581
Irregular	80 (13.8)
Both	117 (20.1)
Missing	7 (1.2)
Medical history	
Pelvic infection or sexually transmitted infection	
Yes	28 (4.8)
No	551 (94.8)
Missing	2 (0.3)
Vaginal infection (yeast infection)	
Yes	224 (38.6)
No	355 (61.1)
Missing	2 (0.3)
Urinary tract infection	
Yes	181 (31.2)
No	398 (68.5)
Missing	2 (0.3)
Cervical procedure, including cryotherapy, loop electrical excision, cauterisation, colposcopy, biopsy	
Yes	16 (2.8)
No	565 (97.3)
Missing	0 (0.0)
Obstetrical/Gynaecological surgery	
One or more procedures	50 (8.6) ^b
Caesarean section	31 (5.3)
Dilation and curettage	15 (2.6)
Other, including laparoscopy	9 (1.6)
No procedure	531 (91.4)
Missing	0 (0.0)
Breast surgery or biopsy	
Yes	26 (4.5)
No	553 (95.2)
Missing	2 (0.3)
Breast feeding (partial)	
Yes	24 (4.1)
No	557 (95.9)
Missing	0 (0.0)

^aBy cohort distributions are available in Table S4.

^bFive women had at least 2 procedures.

TABLE 2

Cycle phase lengths and menstrual bleeding patterns in 581 women^a

Self-reported menstrual characteristics (d)	Percentile				
	Mean (SD)	Min	25th	50th	75th Max
Length characteristics					
Cycle length	30.3 (6.7)	15	27	29	32 98
Length of follicular phase	18.5 (6.5)	5	15	17	20 79
Length of luteal phase	11.7 (2.8)	3	10	12	13 29
Bleeding/spotting characteristics					
Length of menses	6.2 (1.5)	3	5	6	7 15
Menstrual flow score ^b	6.1 (1.5)	1.3	5	6.2	7 11.3
Days of bleeding or spotting in follicular phase ^{c,d}	2.3 (2.5)	1	1	1	2 23
Days of spotting in follicular phase ^{c,d}	2.2 (2.3)	1	1	1	2 23
Days of bleeding or spotting in luteal phase ^e	2.7 (2.1)	1	1	2	3 13
Days of spotting in luteal phase ^e	2.4 (1.8)	1	1	2	3 12

SD, Standard deviation.

^aNumber of cycles and women per variable is available in Table S3.

^bThe mean of the points assigned each day for the first 6 d of the menstrual cycle for heavy bleeding (12), moderate bleeding (8), light bleeding (4), very light bleeding (2), brown bleeding (1), or no bleeding (0).⁹

^cAmong women's cycles with follicular phase bleeding or spotting (255 cycles, 10.0%), or only spotting (252 cycles, 9.8%).

^dDays of bleeding or spotting in follicular phase have been counted from after the end of menses through ovulation day.

^eAmong women's cycles with luteal phase bleeding or spotting (190 cycles, 7.9%), or only spotting (182 cycles, 7.6%).

TABLE 3

Mean cycle phase lengths and menstrual bleeding patterns in 581 women, by parity and age^{a,b}

	Total	Nulliparous ^c		Parous ^c	
		Age < 30	Age 30	Age < 30	Age 30
Number of women	581 ^c	341	68	87	79
Number of cycles	3324	2011	450	403	426
Mean days (95% Confidence interval)					
Length Characteristics					
Cycle length	30.9 (30.4, 31.4)	31.5 (30.8, 32.2)	29.2 (27.8, 30.7)	30.2 (28.9, 31.5)	30.1 (28.8, 31.5)
Length of follicular phase	19.1 (18.6, 19.6)	19.6 (18.9, 20.2)	17.6 (16.2, 18.9)	18.5 (17.3, 19.8)	18.7 (17.4, 20.0)
Length of luteal phase	11.7 (11.5, 11.9)	11.9 (11.6, 12.1)	11.7 (11.1, 12.2)	11.3 (10.9, 11.7)	11.5 (11.1, 11.9)
Bleeding/Spotting Characteristics					
Length of menses	6.2 (6.1, 6.3)	6.2 (6.1, 6.3)	6.2 (5.9, 6.5)	6.5 (6.2, 6.7)	6.2 (5.9, 6.4)
Menstrual flow score ^d	6.1 (6.0, 6.2)	6.1 (6.0, 6.3)	5.8 (5.5, 6.2)	6.3 (6.0, 6.6)	6.1 (5.8, 6.4)
Days of bleeding or spotting in follicular phase ^{e,f}	2.2 (1.9, 2.6)	2.3 (1.8, 2.7)	1.7 (0.6, 2.7)	2.3 (1.6, 3.1)	2.5 (1.5, 3.4)
Days of spotting in follicular phase ^{e,f}	2.1 (1.8, 2.4)	2.1 (1.7, 2.5)	1.7 (0.8, 2.6)	2.3 (1.5, 3.1)	2.5 (1.5, 3.5)
Days of bleeding or spotting in luteal phase ^g	2.5 (2.1, 2.8)	2.5 (2.1, 3.0)	2.4 (1.3, 3.4)	2.6 (1.6, 3.6)	2.3 (1.6, 3.0)
Days of spotting in luteal phase ^g	2.3 (2.0, 2.6)	2.4 (2.0, 2.8)	2.1 (1.2, 3.0)	2.4 (1.4, 3.3)	2.2 (1.6, 2.8)

^aNumber of cycles and women per variable is available in Table S3.

^bLinear mixed models were used to generate least square means.

^cSix women (34 cycles) have missing value for parity.

^dDefinition in Table 2.

^eAmong women's cycles with follicular phase bleeding or spotting (255 cycles, 10.0%), or only spotting (252 cycles, 9.8%).

^fDays of bleeding or spotting in follicular phase have been counted from after the end of menses through ovulation day.

^gAmong women's cycles with luteal phase bleeding or spotting (190 cycles, 7.9%), or only spotting (182 cycles, 7.6%).

TABLE 4

Risk ratios for high variability in cycle phase and menses lengths in 509 women with at least 2 charted cycles, by parity and age^{a,b}

Total proportion 509 ^c women 3252 cycles % (95% CI)		Nulliparous ^c Age 30 (61 women) vs. Age < 30 (301 women)	Parous ^c Age 30 (69 women) vs. Age < 30 (73 women)
Longest cycle—shortest cycle is > 7 d			
Age 30	43.0 (38.7, 47.3)	0.81 (0.58, 1.13)	0.77 (0.47, 1.26)
Age < 30		1.00 (Reference)	1.00 (Reference)
Longest follicular phase—shortest follicular phase is > 7 d			
Age 30	41.7 (37.4, 46.0)	1.01 (0.75, 1.36)	0.84 (0.51, 1.39)
Age < 30		1.00 (Reference)	1.00 (Reference)
Longest luteal phase—shortest luteal phase is > 3 d			
Age 30	58.8 (54.5, 63.1)	1.34 (1.15, 1.57)	1.14 (0.80, 1.62)
Age < 30		1.00 (Reference)	1.00 (Reference)
Longest menstrual flow—shortest menstrual flow is > 3 d			
Age 30	11.6 (8.7, 14.5)	1.18 (0.58, 2.43)	0.63 (0.22, 1.78)
Age < 30		1.00 (Reference)	1.00 (Reference)

CI: Confidence interval

^aNumber of women per variable is available in Table S3.

^bGeneralised linear models were used to generate risk ratios and 95% confidence intervals.

^cFive women (33 cycles) have missing value for parity.