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Rates of anovulation in adolescents and young adults with moderate to severe primary dysmenorrhea and those without primary dysmenorrhea

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Abstract

Objective—To evaluate rates of presumptive anovulation in eumenorrheic adolescents and young adults with moderate to severe primary dysmenorrhea and those without primary dysmenorrhea.

Participants—Thirty-nine adolescents and young adults (ages 16–24) with primary dysmenorrhea and 52 age-matched controls.

Design—Participants completed luteinizing hormone surge ovulation predictor test kits. Anovulatory cycles were defined by never receiving a positive result prior to the next menstrual period; participants were grouped as anovulatory if they experienced at least one anovulatory cycle during study participation. Participants rated daily level of menstrual pain on a 0–10 numeric rating scale.

Setting—A university-based clinical research laboratory.

Results—One hundred and sixty-eight cycles were monitored, 29.8% of which were anovulatory (37.1% vs. 17.5% of cycles in control and dysmenorrhea groups respectively). During study participation, control girls were significantly more likely to have had at least one anovulatory cycle than were girls with primary dysmenorrhea (44.2% vs. 17.9% of participants respectively, $p < .01$). Cycle length and number of bleeding days between ovulatory and anovulatory cycles were similar. The primary dysmenorrhea group's maximum menstrual pain ratings did not differ between ovulatory and anovulatory cycles (4.77 and 4.36 respectively, $p > .05$).

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Conclusion—Data support previous findings of increased rates of ovulation in primary dysmenorrhea. However, menstruation following anovulatory cycles can be as painful as menstruation following ovulatory cycles. These data support the idea that regular menses do not necessarily indicate that a normal ovulatory cycle has occurred. Previous implications that ovulation is necessary for the development of substantial menstrual pain are incomplete.

Keywords

Dysmenorrhea; Anovulation; Adolescent; Young Adult

Introduction

Primary dysmenorrhea (PD) is defined as painful menstruation without an identified anatomic cause.^{1, 2} PD consists of pain in the abdomen, lower back, and/or thighs at the start of or a few days prior to the onset of menstruation and continuing for a few days after menstruation begins, and is frequently accompanied by symptoms of nausea, vomiting, diarrhea, fatigue, and insomnia.^{1, 3–6} PD is estimated to affect between 45–95% of menstruating females,^{2, 7–9} and causes significant work and school absences and decreased quality of life.^{2, 10–12} Despite this impact, PD remains relatively understudied.² Specifically, growing effort has been put forth to further understand the factors contributing to its etiology.

PD is believed to be caused in large part by the overproduction of uterine prostaglandins.^{1, 13–15} The decline in progesterone during the late-luteal phase of ovulatory (OV) cycles creates an environment more favorable for prostaglandin production,¹⁶ which has led to the belief that ovulation is necessary for the development of PD.^{14, 17} Only one published study assessed levels of prostaglandins during OV and anovulatory (AO) cycles. Concentrations of endometrial prostaglandin F_{2α} (PGF_{2α}) were significantly higher in secretory endometrium than in persistent proliferative endometrium.¹⁷ This implies that increased PGF_{2α} levels are associated with ovulation. These results must be generalized with caution due to the very small sample sizes and the fact that the persistent proliferative (AO) group was comprised of women with abnormal menstrual characteristics (i.e., heavy and irregular periods, long duration of menses).

Only one published study has examined frequencies of anovulation in women with and without PD and self-reported regular menstrual cycles. This study, which assessed ovulation using the basal body temperature (BBT) method, found that young women with PD had an anovulation rate of 16.67% whereas those without PD had an anovulation rate of 32.35%, although this difference did not reach statistical significance.¹⁸

Due to the proposed importance of ovulation in the development of menstrual pain, this study focused on the relationship between ovulation and menstrual pain in a sample of adolescent girls and young adult women with regular menses with moderate to severe PD and those without PD. The aims of this study are four-fold: 1) to assess the frequency of presumptive anovulation in a sample of adolescents and young adults with regular menses with moderate to severe PD and those without PD; 2) to compare menstrual characteristics (cycle length and bleeding duration) for OV and AO cycles across all individuals; 3) to

compare pain ratings between OV and AO cycles within the PD group; and 4) to compare menstrual characteristics and pain ratings between OV and AO cycles within the sub-sample of individuals who have PD and experienced both OV and AO cycles during the course of study participation.

Materials and Methods

Participants

Participants were 91 adolescent girls and young adult women ages 16–24 years (52 controls, 39 PD) who were enrolled in a larger laboratory pain-based study investigating central pain mechanisms in PD (see Table 1 for demographic data). Three hundred and fifty-three individuals were screened for eligibility by telephone. Nine individuals (2.5% of total screened) were not interested in participating, and 245 (69.4% of total screened) were excluded as a result of: use of exogenous hormones in the prior 3 months (N=117); irregular, long, or short cycle lengths (N=25); inconsistent patterns of pain (e.g., 25% of periods are very painful but other 75% are not painful; N=25); participant met characteristics of cells that were already full (e.g., participant with PD after that group had been filled; N=25); and other exclusionary reasons (e.g., legal guardian not available; Reynaud's disease; see Figure 1 for complete list; N=6). We also selectively recruited participants with either very little or no menstrual pain or severe or very severe menstrual pain in order to create more distinct groups. Forty-seven individuals were additionally excluded due to having only mild menstrual pain. Of the 99 eligible individuals who were invited to participate, 7 (7.1%) declined participation mainly because of lack of interest or scheduling difficulties. One participant was enrolled in the study but withdrew before completing the ovulation predictor kit, so her data were not included in any analyses. See Figure 1 for a CONSORT-style flow chart depicting study enrollment.

Written informed consent forms were completed by young adult participants, and written assent and parental permission were completed by adolescent participants and a legal guardian. The study was approved by the UCLA Institutional Review Board. Each participant received up to \$250 cash for participation in the larger study.

Procedure

The majority of participants (89.1%) were recruited via mass emails sent to female university students. Additional recruitment methods included: Craigslist posts (2.2%), word of mouth referrals (5.4%), and participants from previous studies (3.3%). Eligibility was confirmed by telephone. A trained research coordinator asked potential participants whether they met any of the following exclusionary criteria: 1) Acute illness or injury that would potentially impact pain task performance (e.g., fever, flu symptoms) or that affects sensitivity of the extremities (e.g., Reynaud's disease); 2) Daily use of opioids at the time of study participation (participants who use other analgesics were included but were requested to not take these analgesics on the day of the laboratory session until after the session); 3) Developmental delay, diagnosis of autism, or significant cognitive impairment that may preclude understanding of study procedures; 4) Use of hormonal contraceptives [e.g., oral contraceptives (birth control pill), contraceptive patch/ring, intrauterine devices, birth control

shot, etc.] in the previous 3 months; 5) Irregular menstrual cycles (<24 or >35 days; lower limit chosen as a conservative cutoff); or 6) currently pregnant. Participants were categorized as having PD if they verbally reported an average menstrual pain rating of “4” or higher on a 0–10 (0=none; 10=worst pain possible) numeric rating scale (NRS). Control participants rated average menstrual pain as “3” or below on the same scale. This method of group classification is consistent with previous studies in PD populations.^{19, 20} Eligible individuals were scheduled for an intake visit during which they provided informed assent/consent and were randomized to the menstrual phase of their first laboratory pain testing visit (menstrual, ovulatory, or mid-luteal). At the intake visit participants were instructed on the use of the ovulation predictor test kit (see below).

Participants were also instructed on the nightly text message procedures. They were told that they would receive a text message each night from our automated text system (or an automated email for those who did not have text messaging capabilities) which would ask them the following four questions: 1) Are you on your period today?; 2) What is your level of pelvic pain today from 0 (no pain) to 10 (worst pain possible)?; 3) If you had pelvic pain, did you take any medication for it? If so, please specify the medication, dose, and how often you took it; and 4) How much has your pelvic pain interfered with daily activities from 0 (no interference) to 10 (complete interference)? Questions used the term “pelvic pain” instead of “menstrual pain” because we wanted to determine if participants experienced any pain in the pelvic area, even when not menstruating. Participants were able to choose what time, between 8 PM and midnight, they would like to receive the nightly texts. The research coordinator followed up the following day with anyone who had not answered the previous night’s text message. Text messages continued until the end of study participation. Global response rate was very high (99.2%); individual response rates ranged from 89.1% to 100%.

Participants’ height and weight were collected during the laboratory visits as part of the larger study (results to be reported elsewhere).

Ovulation Predictor Test Kits

To identify menstrual cycle phase for the laboratory visits, participants completed urinary luteinizing hormone (LH) surge ovulation predictor test kits according to manufacturer’s instructions. Test kit start date was determined by participant’s last menstrual period and average cycle length; kits were started at least several days before anticipated ovulation. Participants were told to contact the study coordinator when the test was positive, and the study coordinator kept in close correspondence with all participants during test kit use. LH surge test kits have demonstrated consistence with direct methods of ovulation detection.²¹ Two different brands of test kit were used in this study: OvuQuick One-Step Ovulation Predictor (Vitrolife, San Diego, CA, USA), and Clearblue Digital Ovulation Test (Swiss Precision Diagnostics GmbH, Geneva, Switzerland). Both kits have been used in previous menstrual phase studies.^{19, 22} Per the manufacturers’ performance characteristics, the sensitivity of both brands of tests (i.e., the magnitude of an LH surge needed to trigger a positive test result) is LH values ≥40mIU/mL. In addition, the ClearBlue test may also indicate a positive result as low as 22mIU/mL depending on the individual’s previous LH levels.

Cycles were considered AO if the participant never received a positive test kit result prior to beginning bleeding, indicating the start of the next menstrual cycle. Participants were grouped as AO if they experienced at least one AO cycle during study participation. Participants completed kits for up to 3 AO cycles before discontinuing the study, as per study protocol. These participants who experienced 3 AO cycles were considered chronically AO for the purposes of the current study. Participants who had an AO cycle continued with cycle monitoring for up to 3 cycles until a cycle was documented to have an LH surge. Participants were permitted to exceed three monitored cycles only if university holidays or extended student vacation times (e.g., spring break/summer break) prevented them from completing a lab visit during an ovulatory cycle which they otherwise would have completed.

Measures

Numeric rating scale (NRS)—Participants used a 0–10 NRS anchored from 0 (no pain) to 10 (worst pain possible) to rate their typical level of menstrual pain without medication on the first day of menstruation. The 0–10 NRS was also used on the nightly text messages to report daily levels of pelvic pain and activity interference due to menstrual pain. The 0–10 NRS is a widely-used and recommended measure of pain intensity^{23, 24} and has been used with adolescent populations.²⁵

Pelvic pain during menstruation—Pain during menstruation was assessed using the nightly text message data and calculating the maximum pain rating and the average daily pain rating for the days of menstrual flow.

Pain medication use—The number of days each period that participants took pain medication for their menstrual pain was calculated. This value was only calculated for the PD group because the control group was defined by not having significant menstrual pain that would warrant medication.

Body Mass Index (BMI)—BMI was calculated from participants' height and weight using the common BMI formula [(weight in pounds/height in inches)² * 703].

Age of menarche was self-reported on a menstrual history questionnaire which was designed for this study and completed on a computer during the intake visit.

Statistical Analyses

A power analysis determined the sample size for the larger study on laboratory pain. No post-hoc power analyses were conducted for the analyses described in this investigation due to the fundamental flaws of post-hoc power analyses^{26, 27} and because the mathematical relationship between *p*-value and power renders post-hoc power analyses unnecessary for this study. Demographic characteristics are expressed as mean (SD) for continuous variables, and frequencies (%) for categorical variables. Group differences were tested using Pearson's chi-square tests (for categorical variables) and independent samples t-tests (for continuous variables). Due to small sample size, the investigation of within-subjects differences in menstrual characteristics and pain ratings between OV and AO cycles was limited to a

presentation of descriptive statistics. A Bonferroni correction was used to reduce the risk of type I error for the two dimensions of analysis (incidence of anovulation and between-subjects pain ratings; $\alpha=.025$). Analyses were performed using SPSS version 22.0 (IBM SPSS Statistics, USA).

Results

Demographic and menstrual history data

One hundred and sixty eight full menstrual cycles during which the participant used a test kit were tracked across the 91 participants. Age, BMI, and race were not significantly different between groups, however, the PD group had a higher proportion of Hispanic participants (38.5% vs 15.4%; $\chi^2=6.28$, $p<.05$). There were no significant differences between OV and AO groups on age, race, ethnicity, or BMI. Control girls were significantly more likely to have had at least one AO cycle (44.2%) than were girls with PD (17.9%) ($\chi^2=6.97$, $p=.008$, see Figure 2). A greater percentage of controls were chronically anovulatory compared to those with PD (11.5% vs. 2.6%), however this result did not reach statistical significance ($p=.11$; see Figure 3). Thirty-nine of the 105 cycles (37.1%) monitored in the control group were anovulatory, whereas 11 of the 63 cycles (17.5%) monitored in the PD group were anovulatory. The average number of cycles tracked per participant was 1.85 (2.02 control group; 1.62 PD group, $t = 2.15$; $p = .035$, not significant due to Bonferroni correction). Age at menarche for the OV group (11.8 years) was significantly lower than for the AO group (12.6 years) [$t = -2.73$, $p = .008$]. The post-menarcheal age (in years) was longer in the OV group compared with the AO group [OV = 9.22 years; AO = 7.94 years; $t = 2.40$, $p=.019$], but there was no significant difference between the control and PD groups in the same measure [control = 8.48 years; PD = 9.22 years; $t = -1.43$, $p = .16$]. The majority of participants (91.2% overall; 90.4% control group, 92.3% PD group) were more than 5 years post-menarcheal (see Table 1 for further breakdown). There was no significant difference in the frequency of AO cycles based on which brand of test kit was used ($\chi^2=.190$, $p=.66$).

Menstrual cycle characteristics

There were no significant differences in cycle length or number of bleeding days between OV cycles and AO cycles in the whole sample ($p's > .05$, see Table 2 for values). There were no significant differences in max pain or average daily pain between OV cycles and AO cycles in the PD group ($p's > .05$, see Table 3 for values). For the sub-sample of individuals in the PD group who experienced both an OV and AO cycle, the average maximum pain during OV cycles was 5.17 compared to 3.75 during AO cycles (see Table 4 for additional descriptive data).

Discussion

In our sample of eumenorrheic adolescents and young adults, girls with moderate to severe PD were significantly less likely to experience AO cycles than those without PD, which supports similar trends observed by others.¹⁸ There were no significant differences in menstrual cycle length or number of bleeding days between OV and AO cycles. Within the PD group, there were no significant differences in maximum or average daily pain ratings

between OV and AO cycles. In the small sub-sample of PD group participants who experienced at least one of each cycle type during study participation, preliminary data indicate that these individuals do experience menstrual pain during AO cycles. The finding that girls with PD demonstrated more OV cycles compared to girls without PD supports the concept that ovulation is a key component in the development of menstrual pain. However, further research in larger samples is needed to adequately determine whether or not the difference in pain levels between OV and AO cycles within the same individual are statistically different.

Our data demonstrating a substantial prevalence of AO in those with PD (17.9%) support the findings of Espin Lopez et al.¹⁸ who concluded that the prevalence rate of AO cycles of 16.67% in the dysmenorrheic group refuted the notion that ovulation is necessary for PD. However, they did not assess pain ratings during each specific menstrual cycle. As presented, it is unknown if a subgroup of individuals in the PD group experienced pain during menstruation during AO cycles, or whether they experienced an occasional pain-free AO cycle. Our data demonstrating that pain levels remain relatively constant, regardless of ovulation status, support and extend these results.

Age at menarche and the number of years since menarche did differ between the OV and AO groups in our sample. This finding is not surprising as the general consensus is that the process of regular ovulation develops over time. By five years after menarche the percent of ovulatory cycles (about 75%) approaches that seen in young adults (about 80%).^{18, 28–30} Although most studies have reported that about half of early adolescents have anovulatory cycles,^{29, 30} others have reported that most girls are ovulatory within a few cycles of menarche.³¹ The discrepant conclusions are probably due to different aspects of an ovulatory cycle (LH surge, preovulatory follicle collapse, progesterone output as a measure of corpus luteum function) being assessed by the various methodologies. It is important to keep in mind, however, that over 90% of our sample was five or more years post-menarche, which may indicate that their menstrual patterns are more similar to those of an adult woman. Further research is needed to determine whether our observed differences are due to the post-menarcheal process of ovulatory regularization, or whether age at menarche may play a role in subsequent patterns of anovulation. Age at menarche and the number of years since menarche did not differ between the PD and control groups, precluding the implication of those variables as the source of our observed differences in rates of anovulation between pain groups.

In this study, a greater percentage of girls in the PD group were Hispanic/Latino as compared to the control group. Racial and ethnic differences have been demonstrated in a wide-ranging spectrum of pain disciplines from experimental pain to clinical pain and pain management,^{32–35} including aspects of menstrual pain.^{36, 37} However, a full review of these differences is beyond the scope of this study. Two possible explanations for our observed differences are: 1) a biological or social/environmental factor underlying the racial/ethnic differences in pain may also contribute to the development of menstrual pain; or 2) the exclusion of girls taking hormonal contraceptives may have introduced a selection bias with regards to race and ethnicity. Knowledge of and use of hormonal contraceptives has been documented to be lower in Hispanic populations than non-Hispanic white populations.^{38–40}

It is feasible that this racial/ethnic disparity extends beyond use of these medications as contraceptives but also as treatment for PD, in which case we may have excluded a greater proportion of non-Hispanic white individuals who were already using hormonal contraceptives for pain control. Further research is required to better understand the role of race, ethnicity, and culture in menstrual pain.

There are several limitations to the current study. First, the relatively small sample size limits generalizability; larger-scale studies are needed to further verify the observed findings. Secondly, it is possible that some of the cycles were misclassified. Although it is possible that cycles were misclassified, this speaks to a larger issue with regard to the reliability of LH surge test kits. LH surge test kits remain the best option for non-invasive, low burden ovulation detection. Throughout this study, cycles were determined to be *presumptively* ovulatory and *presumptively* anovulatory due to the fact that ovulation was not documented via ultrasound or pregnancy. Because we assessed ovulation by detecting LH surge, we did not evaluate the robustness of luteal phase progesterone output, which would have enabled identification of false positive or false negative results. The study as designed is limited by the possibility of such incorrect classifications, though it is reasonable to assume that such rates would occur similarly between the control and PD groups. While LH surge test kit companies claim 99% accuracy in identifying ovulation, this number is usually based on the ability of laboratory tests to identify specific levels of LH.⁴¹ A limited body of literature comparing LH surge ovulation test kits and ultrasound methods of ovulation detection has found agreement rates between the two methods varying from 82–97%,^{42–44} though methodology varies considerably among these studies. It is also possible that ovulation may have been affected by the stress of the protocol, or by the stress of transitioning to independent living in this age group, as has been found by others.²⁸

Because these data were drawn from a larger study on laboratory pain responses, the number of cycles monitored (and therefore the number of test kits used) was not consistent across participants, and this number was low in most participants. Randomization condition was one factor in determining the number of test kits used (e.g., a participant randomized to start the lab visits during the ovulatory phase would not need to use a second test kit to schedule the mid-luteal visit, whereas a participant randomized to start the lab visits during the mid-luteal phase would need to use a second kit during the subsequent menstrual cycle to schedule the ovulatory visit). Other factors contributing to the number of test kits used include inability to conduct a lab visit due to illness, university holidays, or extended student vacation periods. However, the same protocol was used among all participants, so the observed difference between pain groups is likely not due to a systematic bias. Future studies would benefit from assessing ovulation over longer and consistent periods of time in each participant.

We also acknowledge that any discussion of anovulation without incorporating hormonal data is incomplete. We assessed salivary estradiol and progesterone from samples obtained during the lab visits, but no lab visits were conducted during AO cycles so hormone levels during these cycles are unfortunately not available for this investigation. We did not measure the amount of blood lost during the AO vs OV cycles. It has been suggested that lighter menstrual flow is associated with less prostaglandin production,⁴⁵ so amount of flow during

each cycle may be an integral variable to include in future studies. The use of two different brands of test kit could be considered a limitation of the study; however, there was no significant difference in frequency of AO cycles between the two types of kits. Lastly, studies have shown that LH surge ovulation predictor kits tend to indicate higher frequency of anovulation than other measurement types.⁴⁶ However, test kits that detected LH surge were used for all participants in this study, suggesting that our findings may reflect actual differences in rates of ovulation between the groups with and without PD. There is a possibility that higher rates of detection of anovulation with LH surge test kits would confound results for analyses comparing characteristics of OV and AO cycles.

One important implication of the current study is that menstruation with AO cycles is not inherently painless, and that AO cycles can be as painful as OV cycles. This finding is in contrast to previous suppositions regarding PD.^{14, 17} In addition, these data further support the idea that regular menses is not an adequate criterion for assuming ovulation⁴⁷ and therefore the “counting days” method is not scientifically sound.

These data suggest that there may be a complex relationship between ovarian sex steroids and menstrual pain. Previous implications that ovulation is necessary for the development of substantial menstrual pain are incomplete. Given the widespread prevalence and impact of PD, future research should continue to investigate the local uterine and other peripheral and central mechanisms that contribute to dysmenorrhea.

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Figure 1.
CONSORT-style flow chart depicting study enrollment.

Figure 2.

Control girls were significantly more likely to have had at least one AO cycle than were girls with PD (44.2% vs. 17.9% respectively, $\chi^2=6.97$, $p=.008$).

^aPD = primary dysmenorrhea

Figure 3.

A greater percentage of controls were chronically anovulatory compared to those with PD (11.5% vs. 2.6%), however this result did not reach statistical significance ($p=.11$).

^aPD = primary dysmenorrhea

Table 1

Demographic data and menstrual history by pain group, ovulatory group, and for the total sample.

	Control Group (N=52)	PD Group (N=39)	p value	OV group (N=61)	AO group (N=30)	p value	Total (N=91)
Age (years) [Mean (SD)]	20.7 (1.84)	21.1 (2.12)	ns	21.0 (2.09)	20.5 (1.67)	ns	20.9 (1.96)
Ethnicity [N (%)]							
Hispanic/Latino	8 (15.4%)	15 (38.5%)	p=.012	18 (29.5%)	5 (16.7%)	ns	23 (25.3%)
Non-Hispanic/Non-Latino	44 (84.6%)	24 (61.5%)		43 (70.5%)	25 (83.3%)		68 (74.7%)
Race ^b [N (%)]							
White	16 (33.3%)	12 (33.3%)	ns	18 (32.1%)	10 (35.7%)	ns	28 (33.3%)
Black/African-American	3 (6.3%)	4 (11.1%)		7 (12.5%)	0 (0.0%)		7 (8.3%)
Asian	24 (50.0%)	11 (30.6%)		22 (39.3%)	13 (46.4%)		35 (41.7%)
American Indian/Alaska Native	1 (2.1%)	0 (0.0%)		0 (0.0%)	1 (3.6%)		1 (1.2%)
Multi-Racial	4 (8.3%)	9 (25.0%)	ns	9 (16.1%)	4 (14.3%)	ns	13 (15.5%)
BMI ^c [Mean (SD)]	23.1 (3.41)	21.9 (2.78)		22.5 (3.33)	22.6 (2.86)		22.5 (3.18)
Education Level [N (%)]							
Some high school or completed high school	3 (5.8%)	5 (12.8%)	ns	7 (11.5%)	1 (3.3%)	ns	8 (8.8%)
Some college or AA degree	43 (82.7%)	27 (69.2%)		45 (73.8%)	25 (83.3%)		70 (76.9%)
College degree (BA, BS)	5 (9.6%)	6 (15.4%)		8 (13.1%)	3 (10.0%)		11 (12.1%)
Post-graduate degree	1 (1.9%)	1 (2.6%)		1 (1.6%)	1 (3.3%)		2 (2.2%)
Menstrual pain (0–10 NRS) [Mean (SD)]	0.69 (0.78)	7.07 (1.65)	p=.000	4.02 (3.61)	2.22 (2.60)	p=.008	3.42 (3.41)
Age at menarche (years) [Mean (SD)]	12.2 (1.43)	11.9 (1.24)	ns	11.8 (1.21)	12.6 (1.50)	p=.008	12.1 (1.36)
Post-menarcheal age (years) [Mean (SD)]	8.48 (2.47)	9.22 (2.40)	ns	9.22 (2.22)	7.94 (2.71)	p=.019	8.80 (2.45)
Post-menarcheal age (years) [N (%)]							
Fewer than 5 years	5 (9.6%)	3 (7.7%)	ns	4 (6.6%)	4 (13.3%)	p=.034 ^d	8 (8.8%)
5–8 years	15 (28.8%)	6 (15.4%)		10 (16.4%)	11 (36.7%)		21 (23.1%)
More than 8 years	32 (61.5%)	30 (76.9%)		47 (77.0%)	15 (50.0%)		62 (68.1%)
Total number of cycles monitored for ovulation per group	105	63		85	83		168
Number of cycles monitored for ovulation per participant [Mean (SD)]	2.02 (0.96)	1.62 (0.78)	p=.035 ^d	1.39 (0.53)	2.77 (0.82)	p=.000	1.85 (0.91)

	Control Group (N=52)	PD Group (N=39)	p value	OV group (N=61)	AO group (N=30)	p value	Total (N=91)
Number of cycles monitored for ovulation per participant [N (%)]							
1	19 (36.5%)	21 (53.8%)	ns	38 (62.3%)	2 (6.7%)	p=.000	40 (44.0%)
2	16 (30.8%)	13 (33.3%)		22 (36.1%)	7 (23.3%)		29 (31.9%)
3	15 (28.8%)	4 (10.3%)		1 (1.6%)	18 (60.0%)		19 (20.9%)
4-5	2 (3.8%)	1 (2.6%)		0 (0.0%)	3 (10.0%)		3 (3.3%)

^aPD = primary dysmenorrhea; OV = ovulatory; AO = anovulatory; BMI = body mass index; NRS = numeric rating scale.

^bSeven Hispanic/Latino participants (4 control, 3 dysmenorrhea; 5 OV, 2 AO) declined to indicate race because they did not identify with any of the options

^cHeight and weight were assessed at the first lab session, therefore BMI is unavailable for the 4 individuals who completed ovulation predictor test kits but never completed a lab session

^dNot significant due to Bonferroni correction

Table 2

Menstrual characteristics [Mean (SD)] between OV and AO cycles within the whole sample.

	OV	AO	<i>t</i> value	<i>p</i> value
Cycle length (days) – all cycles ^b	30.74 (6.44) N=117	29.17 (5.69) N=47	-1.46	<i>ns</i>
Cycle length (days) – removing outliers ^c	30.01 (4.53) N=114	28.80 (5.16) N=46	-1.46	<i>ns</i>
Number of bleeding days ^d	5.16 (1.45) N=116	5.24 (1.79) N=46	0.31	<i>ns</i>

^aOV = ovulatory; AO = anovulatory

^bFour cycles (all from control participants) were identified as either ovulatory (n=1) or anovulatory (n=3) but exact cycle length is missing and so are not included in this analysis

^cExcludes four additional cycles (3 OV, 1 AO) which were identified by SPSS as outliers for cycle length

^dTwo cycles (1 OV, 1 AO) are missing number of bleeding days and are excluded from this analysis only

Table 3

Pain ratings [Mean (SD)] between OV and AO cycles within the PD group.

	OV N=52	AO N=11	<i>t</i> value	<i>p</i> value
Maximum pain (0–10 NRS)	4.77 (2.23)	4.36 (2.34)	−0.54	<i>ns</i>
Average daily pain (0– 10 NRS)	1.82 (1.15)	2.12 (1.49)	0.74	<i>ns</i>

^aOV = ovulatory; AO = anovulatory; PD = primary dysmenorrhea; NRS = numeric rating scale

Table 4

Descriptive statistics [Mean (SD)] measuring average menstrual characteristics and pain levels between OV and AO cycles in the sub-sample of individuals in the PD group who had at least one of each cycle type (N=6).

	OV	AO
Cycle length (days)	35.08 (15.58)	30.33 (5.32)
Number of bleeding days	6.00 (1.92)	6.25 (1.72)
Maximum Pain (0–10 NRS)	5.17 (1.91)	3.75 (2.56)
Average Daily Pain (0–10 NRS)	2.16 (1.59)	1.97 (1.73)
Days of medication use for menstrual pain	0.42 (0.49)	0.83 (0.75)

^aOV = ovulatory; AO = anovulatory; PD = primary dysmenorrhea; NRS = numeric rating scale