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Original Research

Menstrual cycle–driven vs noncyclical daily changes in sexual desire

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Abstract

Background: Past research on the association between sexual desire and the menstrual cycle has provided inconclusive results and has not considered the potential influence of psychological and physical changes that are frequently associated with the menstrual cycle.
Aim: To test the strength of association between the menstrual cycle (and associated symptoms) and changes in sexual desire.
Methods: Prospective daily reports across 2 full menstrual cycles (2 months) from a sample of female university students (n = 213), were analysed. Analyses tested for average effects of the menstrual cycle on sexual desire, individual differences in these effects, and cyclical and noncyclical associations between sexual desire and the 9 menstrual cycle–related changes. Note that data presented in the current article come from a larger study from which other reports have been published.
Outcomes: Target variables were (1) daily change in sexual desire and (2) daily reports of 5 psychological changes and 4 physical changes that are commonly associated with the menstrual cycle.
Results: Results showed that when considering average effects across participants, the menstrual cycle was associated with a small midcycle increase in sexual desire. However, multilevel analyses showed large individual differences in how the menstrual cycle influences sexual desire. Specifically, some participants showed a midcycle increase, others a perimenstrual increase, and others no change across the menstrual cycle. Moreover, results demonstrated that psychological changes were more important for predicting sexual desire as compared with physical changes.
Clinical Implications: These results suggest that daily measurement of sexual desire across multiple menstrual cycles may be an important tool in the assessment of sexual desire among some females.
Strengths and Limitations: Strengths of this study are the daily assessment of sexual desire and all symptoms for 2 menstrual cycles and multilevel analyses that allow the study of individual differences. Limitations include limited measurement of sexual desire based on only 2 questions and the lack of measures of relationship status and sexual orientation.
Conclusion: Emphasis is placed on the need to apply more rigorous research methods and to abandon simplistic average-effects models that are based on outdated theories and stereotypes.

Keywords: menstrual cycle; sexual desire; psychological symptoms; physical symptoms; multi-level models.

Introduction

Research on quantitative changes in female sexual desire across the menstrual cycle has primarily adhered to an evolutionary perspective linking sexual desire to hormonal changes, fertility, and putative reproductive strategies. Results from this research have been contradictory and inconclusive regarding the extent to which females experience changes in sexual desire across the menstrual cycle, and this research has essentially ignored the potential contribution of physical and psychological changes associated with the menstrual cycle that may also contribute to cyclical changes in desire. Thus, although some authors suggest that clear menstrual cycle effects are present, we actually have a very poor understanding of whether and how sexual desire changes across the menstrual cycle and whether and how physical and psychological changes of the menstrual cycle may influence sexual desire. The aim of the current study is to address these limitations and thus to establish a deeper understanding of how and why sexual desire changes across the menstrual cycle.

Menstrual cycle and sexual desire

According to evolutionary models, females experience an increase in sexual desire and sexual activity around ovulation, during the most fertile days of their menstrual cycle.[1,2] However, while some studies have provided support for this hypothesis,[3-6] there is no consistent pattern of results across studies, and conclusions are often limited by methodological weaknesses. For example, although Stanislaw and Rice[7] concluded that around 50% of their participants experienced a peak in sexual desire around ovulation, because the study was conducted in the context of a "family planning" protocol with prescribed days of sexual activity and when the participants were to record their sexual activity and desire, their results may have been more heavily influenced by the family planning and research protocols than the menstrual cycle and ovulation. Roney and Simmons[8] also concluded that desire peaks around ovulation, yet by examining the data presented, it is clear that the observed changes are better described as a premenstrual decrease in desire rather than a periovulatory

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increase (see also Clayton et al,[9] who found a premenstrual decline vs a periovulatory increase). Bancroft et al,[10] on the other hand, reported an increase in desire in the midfollicular phase but not in the late follicular phase and thus not during the periovulatory phase, whereas Van Goozen et al[11] found a periovulatory peak in desire (ie, around ovulation) only among those with "premenstrual complaints," while those without premenstrual complaints reported higher levels of desire premenstrually. Finally, Bullivant et al[1] went so far as to suggest the existence of a "sexual phase" of the menstrual cycle, which they claimed to replicate across 2 studies, but inspection of the data clearly demonstrates that the pattern of results was not replicated (cf Figures 2 and 3 of study 1 with Figures 4 and 5 of study 2).

In addition to the studies cited here, reviews of the literature have also shown a wide range of inconsistent findings regarding whether and when sexual desire and activity may increase during the menstrual cycle.[12-14] Thus, while some authors suggest that periovulatory increases in sexual desire are a robust finding (eg, Suschinsky et al[15]), the actual data are far from conclusive.

In addition to inconsistent results across studies, one central limitation in this research regards potential individual differences in menstrual cycle–related changes in sexual desire. For example, using daily reports of psychological and physical changes associated with the menstrual cycle, Kiesner et al found that individuals change in very different ways across the menstrual cycle on measures of mood,[16,17] sleep,[18] and headaches.[19] Yet, this research has not been extended to menstrual cycle–related changes in sexual desire or sexual functioning. Thus, to facilitate our understanding of how the menstrual cycle influences sexual desire, individual differences in these putative effects must be explicitly modeled.

Physical and psychological changes of the menstrual cycle

As stated, research on menstrual cycle–related changes in sexual desire has ignored the possible contribution of physical and psychological changes of the menstrual cycle. We suggest that this is a major limitation because the presence of negative changes, such as cramps, headaches, mood swings, depression, and anxiety, could easily be hypothesized to decrease sexual desire. Yet, increases in positive mood states such as happiness may have a positive effect on sexual desire. Although we are aware of no research linking these menstrual cycle–related changes with sexual desire, there is research suggesting that these types of changes, independent of the menstrual cycle, may influence sexual desire. For example, regarding physical symptoms, low levels of sexual desire and functioning have been associated with tension-type and migraine headaches,[20-22] as well as a variety of chronic pain conditions.[23-26]

Regarding psychological symptoms, experimental manipulations of negative mood,[27,28] as well as clinical and nonclinical observational studies,[29-32] have found negative emotions to be associated with lower levels of sexual desire and functioning. Notably, Kalmbach et al[33] reported that daily reports of anhedonia, anxiety, and general distress were associated with decrements in same-day reports of sexual desire and functioning (eg, desire, arousal, lubrication, orgasm, and pain). Moreover, Bittoni and Kiesner[34] examined daily reports of sexual desire in relation to daily reports of mood and found complex nonlinear associations between these variables while statistically controlling for menstrual cycle effects. Finally, sexual desire may be influenced by positive mood. For example, both laboratory-based positive mood induction[35] and positive mood induced by erotic stimulus[36] have been found to be positively associated with subjective sexual arousal and desire but not genital arousal.

Cyclical changes vs noncyclical daily changes

The association between physical and psychological changes and changes in sexual desire may be linked with or independent of the menstrual cycle. For example, cyclical changes in depressed mood or physical pain may be associated with cyclical changes in desire, thus representing a mutual dependence on the menstrual cycle. On the other hand, changes in negative mood or physical pain that are not associated with the menstrual cycle may also influence sexual desire (eg, back and joint pain or negative mood that occurs in an unpredictable way with regard to the menstrual cycle). The present study examines both types of effects.

Current study

The core aim of the present study is to test for putative effects of the menstrual cycle on changes in female sexual desire. This is done by examining how sexual desire, on average, changes across the menstrual cycle and how individuals differ from each other in these changes. Moreover, we also test whether common physical and psychological changes of the menstrual cycle covary with sexual desire, both cyclically across the menstrual cycle, as well as on a daily basis, after controlling for menstrual cycle effects. Finally, we test for individual differences in mean levels of change in sexual desire, as an indication of a trait-like characteristic of sexual desire. Overall, this study provides the most in-depth analysis of how the menstrual cycle and its associated physical and psychological changes are associated with changes in sexual desire.

It should be noted that the data presented here are from a larger study focusing on various changes of the menstrual cycle and from which previous reports have been published. However, these earlier reports focused on very different questions and variables.[16,18,19,34] So, although there is significant overlap in the Methods section of the present report and those of earlier reports, the research questions addressed are very different.

Methods

Earlier reports based on the data presented here have focused on menstrual cycle–related changes in negative mood,[16] sleep,[18] and headaches.[19] However, only the current study and that by Bittoni and Kiesner[34] have examined sexual desire, and these 2 studies address very different questions. For example, Bittoni and Kiesner focused on nonlinear associations between negative mood and sexual desire while controlling for effects of the menstrual cycle, whereas the current study focuses on how sexual desire may be influenced by the menstrual cycle and by cyclical and noncyclical changes in a set of physical and psychological changes commonly associated with the menstrual cycle. So, although there is significant overlap in the Methods section of the present report and earlier ones, the research questions, variables

considered, and analyses conducted are fundamentally different.

Participants

Participants were 213 female university students with a mean age of 21.29 years (SD = 4.01). All first-year female psychology students were asked to participate, and efforts were made to include participants with and without menstrual difficulties. For instance, emphasis was placed on the importance of including participants who have very different experiences during the menstrual cycle; thus, it would be equally important for those with and without menstrual cycle difficulties to participate. Individuals were excluded if they were using hormonal contraceptives or therapy. Individuals were included if they were diagnosed with a psychological or medical condition for which they had been or were being treated. Participants with a seasonal illness (cold/flu) at the time of their next menstrual flow were asked to wait until they recovered before starting (ie, waiting until the onset of a subsequent menstruation). Participation was anonymous and voluntary and did not result in compensation. The Ethics Committee of Psychological Research of the University of Padova approved this study, and all participants signed a consent form.

Of the 897 individuals who were invited to participate, 320 (36%) responded positively and 577 (64%) responded negatively. Of those 320 who agreed to participate, 213 (67%) participated for the full study, providing daily reports for 2 full cycles. The data from these 213 participants are analyzed in the present study.

The average length of the 2 menstrual cycles was 29.6 days for cycle 1 and 30.5 days for cycle 2 (average length of 2 consecutive cycles, 60 days). The average number of questionnaires for each participant was 55. Thus, on average, participants missed only 5 daily questionnaires across the 2 menstrual cycles, and 11 735 questionnaires were included in the following analyses.

Measures

Online daily questionnaire and procedure

With the use of an individual password, participants had access to an online daily questionnaire. All questions referred to the last 24 hours. All responses were given on a 5-point response scale ranging from *not at all* to *very much*. Participants were asked to begin completing questionnaires on the first or second day of menstruation and to indicate on which day they were starting. Participants were asked to complete 1 questionnaire each day but were allowed to complete 1 questionnaire for the prior day and 1 questionnaire for the actual day. Of the total number of questionnaires in the present analyses (n = 11 735), 74% were completed on the actual day and 26% for "yesterday."

Sexual desire

Sexual desire was measured with 2 questions: 1 asking about increased sexual desire and 1 asking about decreased sexual desire. Both questions were preceded with "In the last 24 hours" and were followed by "did you experience an increase in sexual desire?" and "did you experience a decrease in sexual desire?" A difference score was calculated by subtracting decrease in desire from increase in desire (increase – decrease) and used as the dependent variable in all analyses. Thus, negative scores indicate a perceived decrease in sexual desire during the past 24 hours, whereas positive scores represent a perceived increase in sexual desire during the past 24 hours.

Psychological changes

The following 5 psychological change constructs were measured: anxiety, depressed mood, happiness, mood swings, and energy. These constructs were measured via 12 questions, which are listed separately for each construct in Table 1. Except that for "happiness," these questions have been used before,[17] and all are consistent with validated daily-diary assessment methods of menstrual cycle symptoms.[37,38] Results from the confirmatory factor analysis (CFA) model provided the following fit indices: comparative fit index = 0.97, nonnormed fit index = 0.96, root mean square error of approximation = 0.07 (all standardized factor loadings >0.74 and intraconstruct correlations $|r| < 0.64$; see Supplementary A for CFA methods).

Physical changes

The following 4 physical change constructs were measured: back/joint pain, breast changes, cramps, and headaches. These constructs were measured with 7 questions, which are presented in Table 1 and listed separately for each construct. These questions have been used before,[17] and all are consistent with validated daily-diary assessment methods of menstrual cycle symptoms.[37,38] The same CFA modeling approach that was used for psychological constructs was used for physical constructs (see Supplementary A for methods; comparative fit index = 1, nonnormed fit index = 1.008, mean square error of approximation = 0.00; all standardized factor loadings >0.70 and intraconstruct correlations $|r| < 0.39$).

Time

Because the focus of the present study was on changes in sexual desire across time, the time and date of completion for each questionnaire were recoded to represent the proportion of each cycle that had passed (day within cycle / total number of days in that cycle). Therefore, all participants, regardless of how many days their cycle lasted, were put on the same metric, ranging from 0 to 1 for each cycle (1 was then added to all days in the second cycle). Thus, the time variable ranged from 0 to 2, with 0 corresponding to the first day of the first cycle, 1 to the last day of the first cycle, and 2 to the last day of the second cycle.

Data analysis

The aims of the following analyses were to estimate (1) the variance in daily changes in sexual desire that is attributable to mean-level differences across participants; (2) the average effect of the menstrual cycle on daily changes in sexual desire, as well as the individual differences in those effects; (3) the associations between noncyclical daily changes in the 9 physical and psychological constructs and noncyclical daily changes in sexual desire; and (4) the associations between cyclical changes in sexual desire and cyclical changes in the 9 physical and psychological constructs.

Because the effect of the menstrual cycle is modeled as a cosine coefficient of time (time = proportion of the 2 menstrual cycles that has passed), it is important to first describe how these coefficients should be interpreted. Cosine coefficients capture a cyclical "wave" form in change across time, providing a single coefficient that gives the direction and amplitude of cyclical changes across the menstrual cycle.[17]

Table 1. Items used to measure change in symptoms.

Type: symptom	Question: In the last 24 hours . . .
Psychological	
Anxiety	Did you feel anxious?
	Did you feel tense or nervous?
Depressed	Did you feel depressed?
	Did you feel sad?
	Did you feel down?
Happy	Did you feel happy?
Mood swings	Did you have mood swings?
	Did you feel like you were losing control (eg, anger attacks)?
	Did you feel irritable?
	Were you bothered by things that don't normally bother you?
Energy	Did you feel like you had less energy?
	Did you feel like everything you did was an effort?
Physical	
Back/joint pain	Did you have back pain?
	Did you have joint pain?
Breast changes	Did you have changes in breast sensitivity?
	Did you have breast swelling?
	Did you have breast pain?
Cramps	Did you have lower abdominal cramps or pain?
Headaches	Did you have a headache?

With the present data, a negative cosine coefficient indicates a midcycle increase in sexual desire, whereas a positive cosine coefficient indicates a midcycle decrease in sexual desire. The cosine regression slopes for the overall sample and a subset of 21 participants are presented in Figure 1.

Technical aspects of all analyses are presented in Supplementary A. Demographic information on the sample is presented in Supplementary B, including diagnoses and pharmacologic treatments. Eighteen participants reported a diagnosis for which they had been or were being treated. All analyses were conducted on the full sample and a reduced sample excluding the 18 participants with a diagnosis, and overall there were no or very small variations in results. The following results are based on the full sample. In those cases where small variations were observed, they are noted in parentheses.

Results

Partitioning of variance

The current block of analyses focuses on partitioning the variance into that attributable to mean-level differences across participants, menstrual cycle effects, and individual differences in menstrual cycle effects, and was completed using three analytic models.

The first model included only random intercepts of sexual desire (daily observations nested within person) and explained 21.5% the overall variance (intraclass correlation coefficient = 0.215; variance component estimate = 0.44; 90% credible interval = 0.36-0.52; for the reduced sample, 22.2% of the overall variance was explained). In other words, 21.5% of the overall variance in changes in sexual desire is explained by between-person differences in mean levels of sexual desire. Thus, it can be interpreted as about one-fifth of the overall variability in changes in sexual desire is attributable to a trait-like stable characteristic that differentiates individuals, at least within the 2 menstrual cycles examined in this study.

In the second model, the fixed effect of the cosine function of time (average effects of the menstrual cycle) was added to the previous model, thus testing for group-level cyclical changes in sexual desire for the entire sample, which resulted in a cosine regression coefficient of −0.24 (90% credible interval = −0.27 to −0.22). The negative sign of the cosine regression coefficient indicates that, on average, participants experienced an increase in desire around the midcycle, or close to ovulation. However, the within-person variance explained by this average effect of the cosine function was 1.6%; thus, although credible, this effect is small.

Finally, in the third model, the random effect of the cosine function (individual-level effects of the menstrual cycle) was added to the previous model and resulted in a variance component estimate of 0.19 (90% credible interval = 0.15-0.23). The percentage of within-person variance explained by individual differences in the effect of the menstrual cycle was 7.8% (7.7% for the reduced sample). Thus, the effect size for these random effects of the menstrual cycle is >4 times greater than the effect size of the fixed effect of the menstrual cycle: this indicates that the average effect of the menstrual cycle is not sufficient for describing individual-level change in sexual desire across the menstrual cycle, and it confirms the presence of individual differences in how sexual desire changes across the menstrual cycle.

The cosine regression slope illustrating the fixed effect of the menstrual cycle on sexual desire for the entire sample is presented in the left panel of Figure 1, whereas individual slopes for a subsample of 21 participants are presented in the right panel. Note that the participants in the right panel were selected to illustrate the between-person variability in menstrual cycle effects found in the statistical analyses. As observed in these figures, although there is a tendency to experience a small midcycle (ovulatory) increase in sexual desire, many participants show no such change, and others demonstrate the opposite pattern (ie, a midcycle decrease in sexual desire).

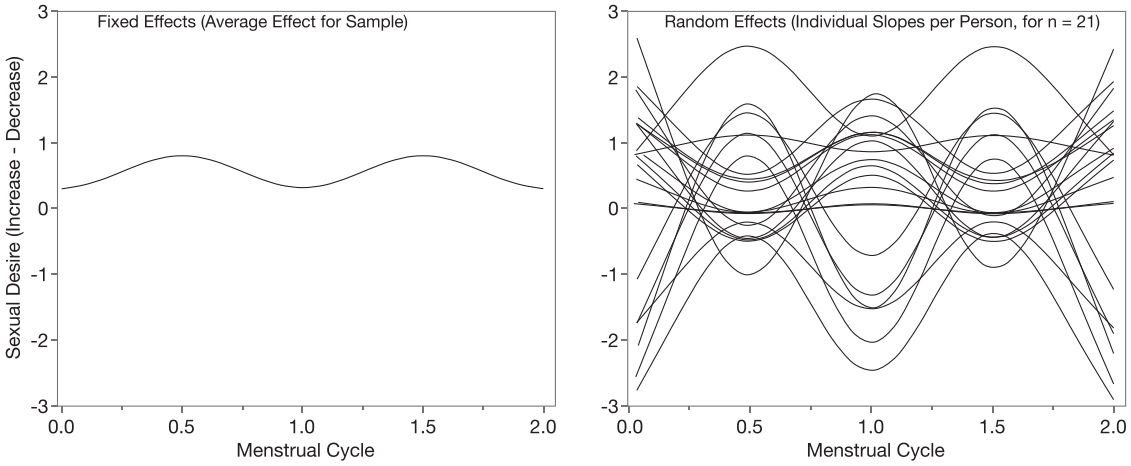

Figure 1. Cosine regression lines showing cyclical change in sexual desire across 2 menstrual cycles: left panel, the average cyclical change for the entire sample; right panel, the cyclical change for a subset of 21 participants, chosen to demonstrate the variability in cyclical change across individuals. Note that of the 18 participants with a diagnosis (see Supplementary B), only 1 is included in the right panel, presenting individual regression lines, and is represented by 1 of the 2 nearly flat lines that has an intercept at approximately zero.

Day-to-day covariations in sexual desire and psychological and physical changes

The current block of analyses tests for day-to-day covariations between sexual desire and psychological and physical symptoms. Although model selection was conducted with a multistep leave-one-out procedure to select the most informative and parsimonious set of predictors to include in the model (see Supplementary A), only the final "best model" is presented here.

Table 2 presents results from the final best model for noncyclical daily changes in sexual desire, as a function of noncyclical daily changes in physical and psychological constructs, while controlling for fixed and random effects of the menstrual cycle. Four of the 5 psychological constructs contributed to the model explaining noncyclical daily changes in sexual desire, whereas just 1 physical construct contributed to improving prediction. Altogether, these 4 psychological constructs and the 1 physical construct explained 4.5% of the within-person variance in noncyclical daily changes in sexual desire, controlling for fixed and random effects of the menstrual cycle. As expected, happiness was positively associated with changes sexual desire (ie, high levels of happiness were associated with increased sexual desire), whereas depressed mood, mood swings, low energy, and back/joint pain were all associated with decreased sexual desire. It is worth noting that happiness is the strongest predictor of change in sexual desire as compared with all other psychological and physical constructs.

Covariation of cyclical change in sexual desire and in psychological and physical constructs of the menstrual cycle

The current block of analyses focuses on the covariation between menstrual cycle–related cyclical change in sexual desire and that in physical and psychological constructs associated with the menstrual cycle. As with the previous block of analyses, although model selection was conducted with a multistep leave-one-out procedure to select the most informative and parsimonious set of predictors to include in the model (see Supplementary A), only the final "best model" is presented here.

Table 3 presents results for the best model predicting menstrual cycle–related cyclical change in sexual desire with that in the physical and psychological constructs. Only cyclical change in depressed mood was credibly associated with cyclical change in sexual desire. Of the overall variance in menstrual cycle–related change in sexual desire, 7% was explained by menstrual cycle–related cyclical change in depressed mood.

It is possible that the overall lack of cyclical effects for the other physical and psychological constructs is an artifact of low signal in the data (eg, the cosine coefficients for all constructs could be unreliable or contain high levels of error, thus attenuating the estimated effects). If true, one could expect to find low correlations among cyclical change in all the measured constructs. Therefore, we examined the bivariate correlations among cyclical change (cosine coefficients) in all physical and psychological construct scores. These correlations are presented in Table 4. The correlations range from $r < 0.01$ to $r = -0.65$, and the overall pattern is consistent with what would be expected if the cosine coefficients carried true information on cyclical change of constructs that are known to be correlated. For example, cyclical change in anxiety and that in depressed mood are positively correlated ($r = 0.64$), whereas cyclical change in anxiety and that in depressed mood are negatively correlated with cyclical change in happiness, although cyclical change in happiness is more strongly correlated with that in depressed mood ($r = -0.65$) than with that in anxiety ($r = -0.32$). Thus, the lack of associations between cyclical change in sexual desire and that in the set of physical and psychological constructs does not appear to be a methodological artifact of poor measurement.

Discussion

Table 5 presents a summary of the results and illustrates the central importance of individual differences when attempting to explain variance in sexual desire. This is true regarding mean levels of sexual desire and their cyclical changes associated with the menstrual cycle. It is clear from these data that the concept of an "average level" or "average effect" has little significance for defining the effect of the menstrual cycle on change in female sexual desire. A second important theme

Table 2. Best-fitting model predicting day-to-day changes in sexual desire from menstrual cycle (cosine) and day-to-day changes in psychological and physical symptoms.

		90% credible interval			Effective sample size	
Predictor	Estimate[a]	Lower	Upper	Rhat function	Bulk	Tail
Fixed effects[b]						
Intercept	0.56 (0.57)	0.48	0.64	1.01	633	1127
Cosine	−0.17 (−0.18)	−0.22	−0.11	1.00	1811	3608
Depression	−0.07	−0.10	−0.03	1.00	6108	5139
Happy	0.24 (0.25)	0.21	0.26	1.00	8389	5880
Mood swings	−0.03 (−0.02)	−0.06	0.00	1.00	7820	5787
Low energy	−0.12	−0.14	−0.09	1.00	7899	6278
Back/joint pain	−0.07 (−0.08)	−0.10	−0.04	1.00	8562	6431
Random effects						
Intercept	0.44 (0.46)	0.37	0.52	1.00	1103	2266
Cosine	0.18	0.14	0.22	1.00	2496	4006
Correlation	0.08 (0.10)	−0.06	0.21	1.00	2084	3722

[a]Numbers in parentheses are results for reduced sample, only when different from full sample, and only listed for "Estimate". [b]All physical and psychological symptom scores were within person centered.

Table 3. Best-fitting model predicting cyclical change in sexual desire (cosine of sexual desire) with cyclical changes in psychological and physical symptoms (cosines of all symptoms).

		90% credible interval			Effective sample size	
Predictor	Estimate[a]	Lower	Upper	Rhat function	Bulk	Tail
Intercept	−0.24 (−0.25)	−0.29	−0.18	1.00	5890	4371
Depressed	−0.13	−0.18	−0.07	1.00	5534	4190

[a]Numbers in parentheses are results for reduced sample, only when different from full sample, and only listed for "Estimate".

Table 4. Correlations among cosine factor scores (or single items) for all psychological and physical symptoms.[a]

	Anxiety	Depression	Happy	Mood swings	Low energy	Headaches	Breast	Cramps
Anxiety	—							
Depression	0.64***							
Happy	−0.32***	−0.65***						
Mood swings	0.63***	0.59***	−0.37***					
Low energy	0.39***	0.46***	−0.37***	0.49***				
Headaches	0.26***	0.29***	−0.19**	0.35***	0.38***			
Breast	0.19**	0.22**	−0.16*	0.28***	0.25**	0.05		
Cramps	−0.00	0.09	−0.12	0.20**	0.28***	0.15*	0.26**	
Back/joint pain	0.27***	0.28***	−0.25**	0.41***	0.52***	0.40***	0.43***	0.45***

[a]No correlations differed by >|0.04| between the full and reduced samples. *$P < .05$. **$P < .01$. ***$P < .0001$.

that emerges from the current findings regards the greater relevance of psychological constructs relative to physical constructs for understanding sexual desire. In this regard, noncyclical daily changes in happiness, depressed mood, mood swings, and low energy were associated with noncyclical daily change in sexual desire, while among the physical constructs, only back/joint pain was associated with sexual desire. Note that the associations between change in sexual desire and all predictor constructs were independent of the menstrual cycle with the exception of depressed mood, which did demonstrate a menstrual cycle–related association with change in sexual desire.

Differences in average levels of sexual desire

Differences in average levels of sexual desire across people could derive from differences in type and/or quality of relationship,[39,40] psychiatric and psychosexual history,[41] level of sexual functioning,[42] and/or trait-like personality characteristics.[43] One such trait-like characteristic is erotophobia/erotophilia, proposed by Fisher et al[44] to define how individuals vary along a continuum in their affective response toward sexual stimuli, ranging from very negative to very positive. Alternatively, the dual control model[45] suggests that individuals differ in their disposition to get "turned on" or "turned off" when exposed to sexual stimuli, and these differences are determined by 2 distinct neurologic subsystems responsible for sexual excitation and sexual inhibition. These models are not mutually exclusive and may function with other variables, such as relationship status, to create relatively stable individual differences in sexual desire.

Fixed and random effects of the menstrual cycle on sexual desire

Past research and theory from multiple perspectives, including evolutionary psychology[46,47] and psychoendocrinology,[8,10,11] have tended to adhere to a basic assumption that cyclical changes in reproductive steroids would predict orderly cyclical changes in sexual behavior, with a significant increase in sexual desire around ovulation. Results from the present study suggest that at the group level this does not

Table 5. Summary of findings.

Domain: type of effect	Variance explained, %	
Intercept		
Random effect	21.5	
Menstrual cycle		
Fixed effect	1.6	
Random effect	7.8	
Type: symptom	**Day-to-day[a]**	**Cyclical**
Psychological		
Anxiety		
Depression	✓	✓
Happy	✓	
Mood swings	✓	
Low energy	✓	
Physical		
Back/joint pain	✓	
Breast changes		
Cramps		
Headaches		
Variance explained, %	4.5[b]	7[c]

[a] Predictor symptom scores were within person centered. [b] Of within-person variance in sexual desire, controlling for menstrual cycle effects. [c] Of the variance in menstrual cycle-related changes in sexual desire.

hold, whereas at the individual level it appears true for some females but not others. This is evident because the magnitude of the group-level effects is so small, relative to the observed individual differences, that it becomes increasingly difficult to sustain the hypothesis of important group-level effects (average effects) of the menstrual cycle (ovulatory increases in sexual desire).

One possible explanation for this wide range of individual differences is that genetic variations in steroid receptors moderate the effects of steroid hormones. A useful model of such an effect was presented by Vermeersch et al,[48] who showed that, among adolescent boys, the effect of testosterone on depressive symptoms is dependent on length of the CAG repeat in the androgen receptor gene, resulting in clear individual differences in response to testosterone. Research more directly related to receptors for "female" reproductive steroids has shown an association between having a diagnosis of premenstrual dysphoric disorder and 4 single-nucleotide polymorphisms in intron 4 of the *ESR1* gene.[49] Although similar research has not been conducted on sexual desire, these early findings provide a promising direction for understanding the complexities of steroid effects on sexual desire and functioning. Thus, we argue that future research examining steroid and menstrual cycle effects on sexual desire should prioritize tests of individual differences in response to steroids and steroid change.

Noncyclical effects of psychological and physical constructs

The current results suggest that cyclical changes in sexual desire that do occur for some females are largely independent of other menstrual cycle–related changes/symptoms. That is, cyclical changes in desire do not depend on cyclical changes in other experiences, with the exception of depressed mood. Yet, noncyclical daily changes in happiness, depressed mood, mood swings, low energy, and back/joint pain were all credibly associated with noncyclical daily changes in sexual desire, thus indicating that psychological changes and back/joint pain are all important at the noncyclical level.

The association between daily changes in low energy and those in sexual desire is consistent with findings from other areas of research linking tiredness/fatigue with sexual functioning. For example, in a sample of women with multiple sclerosis, fatigue was the strongest predictor of sexual dysfunction among a set of 11 predictors, including age, disease duration, disability, and mood[50] (see also Glazener[51] for an example related to postpartum tiredness and sexual function). Thus, albeit indirect, there are multiple lines of research linking tiredness with sexual desire and functioning.

Our finding that noncyclical daily changes in depressed mood are negatively associated with noncyclical daily changes in sexual desire is consistent with a long line of research linking depression with sexual desire and functioning.[30,52-54] However, the present study makes the novel contribution of focusing on daily changes, as opposed to group-level effects on onetime retrospective accounts of sexual desire (eg, Kennedy et al[53]; Kalmbach et al[33] also used daily diaries but for just 2 weeks). Thus, in addition to avoiding recall bias and memory distortion, the present data allowed us to examine types of associations that simply could not have been examined in past research. Specifically, we tested for and found day-to-day and cyclical covariation between sexual desire and negative affect across multiple menstrual cycles.

The present study is the first that we are aware of to emphasize the role of happiness in sexual desire, and our results showed that as compared with all other predictors, happiness demonstrated the strongest association with sexual desire. An interesting exception comes from Kalmbach et al,[33] who reported effects of anhedonia on sexual desire. However, because their measure of anhedonia was based on questions of happiness that were reverse coded ("felt like I had a lot to look forward to," "felt really happy"), those results likely represent associations between sexual desire and happiness (the original questions) rather than sexual desire and anhedonia (an inference based on reverse coding of the original questions). Thus, a specific focus on happiness, independent of negative mood, should be included in future studies.

Our data show that noncyclical daily changes in mood swings are negatively associated with noncyclical daily

changes in sexual desire. Although past theory and research have not addressed this association and therefore our comments will be speculative, one possibility is that sexual desire requires a stable mood state. For example, while a person can be in either a positive mood or a negative mood and still experience sexual desire,[34,55-57] it could be hypothesized that if one's mood state is to change rapidly, then the mental state of sexual desire may be interrupted/lost and the state of sexual desire may need to be reestablished in the new mood state. That is to say, the state of sexual desire would not be transitive across different mood states in the context of rapidly changing moods. More research on this issue is clearly needed before valid conclusions can be drawn.

Finally, the only physical construct that showed an association with sexual desire was back/joint pain. This finding adds to previous reports of moderate to high rates of sexual difficulties among patients with diverse types of chronic pain.[23,24,26] Moreover, actual physical pain and the fear of exacerbating that pain during sex have been implicated as negatively influencing sexual activity.[23,26] To explain these associations, Sjogren and Fugl-Meyer[26] suggested that physical pain and fear of pain may produce a shift of attention away from pleasurable genital sensations, thus resulting in a cognitive interference in sexual desire or response (see Barlow[58] and Cuntim and Nobre[59] for relevant work on cognitive interference in sexual response).

Cyclical changes in depressed mood and sexual desire

Finally, depressed mood was the only construct to demonstrate cyclical covariation with sexual desire. We suggest that there are 3 possible explanations for this association. First, depressed mood and sexual desire may simply be 2 of many variables that change across the menstrual cycle, and there is nothing specifically interesting about their cyclical covariation. This seems unlikely since cyclical change in most of the predictor constructs was correlated with cyclical change in most of the others but not with that in sexual desire. A second possibility is that cyclical change in one variable causes cyclical change in the other—for example, cyclical change in depressed mood causes that in sexual desire. This seems like a very plausible explanation for the observed results. Finally, cyclical changes in steroids may create cyclical changes in brain structures or pathways, including neurotransmitters or mediators of signaling pathways, or in effective connectivity, that are specific and common to depressed mood and sexual desire but are not shared with other changes. This model is also consistent with the observed results, but trying to define those specific structures and pathways is beyond the scope of the present study.

Limitations

There are 5 important limitations of the present study. First, participants were not queried about their sexual orientation; therefore, no conclusions can be made regarding the generalizability of these findings to any specific orientation. Second, participants were not asked about relationship status. This is important because research by Caruso et al[3] showed that sexual activity in those with a partner was less variable across the menstrual cycle, while sexual activity among those without a partner showed a clear peak in the periovulatory phase. Third, measurement of desire was based on only 2 questions, without providing a definition or a specific context, such as desire for partnered sex vs masturbation. Given that sexual desire is likely a complex construct in terms of cause and phenomenology, more attention should be devoted to using measures that tap the complex nature of this experience. By providing examples and definitions (eg, partnered vs solitary sex), we will have more confidence that we are measuring the same experience across participants. Fourth, future prospective studies could include indices of precise ovulation day (eg, using urinary luteinizing hormone surge testing or basal body temperature) to rule out the possibility that measurement error is responsible for a lack of midcycle effects, which could be highly specific to the hormonal events in the days surrounding ovulation (see Schmalenberger et al[60] for discussion on methods of studying the menstrual cycle). Finally, although we did measure a variety of physical changes that are associated with the menstrual cycle, we did not measure physical changes linked with sex, such as vaginal dryness or pain during or after intercourse, which have been associated with low sexual desire.[61] These important variables, as well as sexual orientation and relationship status, were not measured in the present study because the focus of the original study was on psychological and physical changes of the menstrual cycle, not sexuality. Thus, these important additions will need to be addressed in future research. Note that while the data analyzed in the present article come from a larger study from which other reports have been published, the use of daily reports for 2 months—to examine how sexual desire changes across the menstrual cycle and in relation to cyclical and noncyclical changes in psychological and physical symptoms—represents the most ambitious analysis of potential menstrual cycle effects on sexual desire ever conducted.

General conclusions

This study contributes to a growing body of research suggesting that, similar to socially destructive stereotypes, outdated scientific conceptions of how the "average female" responds or should respond to the menstrual cycle must be abandoned. This includes simplistic theories of female reproductive behavior in evolutionary terms that predict a common and inevitable change in sexual interest and behavior that have previously not been rigorously tested. It also underlines the importance of applying more rigorous research designs involving high-frequency repeated measures in combination with multilevel statistical analyses that allow the examination of individual differences in sexual desire and behavior across the menstrual cycle. Only through these approaches will we be able to understand the relative contribution of individual differences vs group-level effects.

Supplementary material

Supplementary material is available at *The Journal of Sexual Medicine* online.

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