Menstrual Synchrony: Fact or Artifact?

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Although more than thirty years of intensive investigation have passed since McClintock first published results on menstrual synchrony, there is still no conclusive evidence for the existence of this phenomenon. Indeed, a growing body of null-result studies, critiques of menstrual synchrony studies, and the lack of convincing evolutionary explanations bring into question the existence of this phenomenon. This paper presents results of a study conducted over five consecutive months in Polish student dormitories. In 18 pairs and 21 triples of college-age women, menstrual synchrony was not found. Social interactions, considered the most important factor mediating the effect of menstrual synchrony, was unrelated to any difference in menstrual cycle onsets. Initial menstrual onset difference was influenced by woman's body mass and menstrual cycle irregularity. These results provide further evidence that women do not synchronize their menstrual cycles.

KEY WORDS: Menstrual cycle; Menstrual synchrony; Social interactions

Martha McClintock (1971) first reported the apparent influence of social interactions on menstrual cycles of women living in a college dormitory. In that study, 135 women, age 17 to 22, living in single or double rooms, were asked to recall (*a*) their last and second to last menstrual period three times during the school year, (*b*) time spent each week in the company of men, and (*c*) the list of girls they consider their best friends. Statistically significant effects of menstrual synchrony were reported for pairs of friends and groups of friends, which subsequently led to more than thirty years of intensive interest in the phenomenon of menstrual synchrony and its mechanisms. Subsequent studies have been conducted on various groups of women, for example, roommates (Graham and McGrew 1980; Jarett 1984;

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Weller et al. 1995; Wilson et al. 1991), coworkers (Matteo 1987; Weller and Weller 1995a), athletes (Weller and Weller 1995b), lesbian couples (Trevathan et al. 1993; Weller and Weller 1992, 1998), and women from natural fertility populations (e.g. Strassmann 1997).

Several studies reported conditions necessary for the occurrence of menstrual synchrony. The degree of exposure to pheromones has been regarded as the most important fact. Friendship, common activities, and amount of time living together determine frequency and intensity of contact between women and thus the level of exposure to pheromonal stimuli (Goldman and Schneider 1987; Weller and Weller 1993a).

The hypothesis of a putative pheromonal mechanism for menstrual synchrony found support in a laboratory experiment (Stern and McClintock 1998). Stern and McClintock (1998) reported two kinds of odorless compounds from the armpits of women (i.e., pheromones), when presented to participants, regulated their menstrual cycle lengths. They hypothesized that the lengthening or shortening of cycles was caused by ovarian-based pheromones that accelerated or delayed the surge of luteinizing hormone and thereby shortened or lengthened menstrual cycles.

However, the literature provides far from conclusive evidence for the existence of menstrual synchrony. The phenomenon has been brought into question by theoretical, methodological, and follow-up empirical studies. Using a mathematical model, Wilson (1992) showed that menstrual synchrony should be expected in half of the studied cases without any external cause producing it. The probability of occurrence of this phenomenon should be greatest in the beginning of an observational period and decrease to expected values on subsequent observations. He also found three methodological errors that appeared in previous studies and might increase the probability of observing synchrony when in fact it has not occurred: (1) too short a period of observation, (2) incorrect methods of calculating the menstrual onset differences, and (3) exclusion of particular subjects from the analysis.

Strassman (1995) and Schank (2000) pointed to the role of menstrual cycle variation among and within individual women as a mathematical obstacle for the synchrony occurrence. Two or more rhythms cannot be synchronized if they do not share the same frequency. Between-women cycle variability mathematically implies different frequencies. With regard to studies conducted by Weller and Weller (1993b, 1995a), Schank (2000) showed how a false assumption that all menstrual cycles have the same, stable length can produce the bias toward finding menstrual synchrony. He concluded that both within—and between-women cycle variability makes menstrual synchrony over time a "mathematical impossibility" and that "finding synchrony may be an indicator of methodological artifact rather than a phenomenon." In fact, many observational studies conducted in urbanized and non-natural fertility societies were unable to demonstrate this phenomenon (Jarett 1984; Trevathan et al. 1993; Weller and Weller 1995b, 1998; Weller et al. 1995; Wilson et al. 1991). Perhaps most importantly, menstrual synchrony was not observed in a natural fertility population (Strassmann 1997, 1999).

Another interesting problem concerns the evolutionary explanation of menstrual synchrony. Several evolutionary hypotheses have been proposed to explain it (Burley 1979; Frisch 1984; Knowlton 1979; Turke 1984). Burley (1979) suggested that menstrual synchrony evolved in human ancestors as a mechanism for increasing the conception probability in females living as co-wives of one male. In such a situation, a male who has the ability to detect pheromonal signals would have been attracted by one strong stimuli from all his co-wives, which would increase the probability of conception for each female. Knowlton (1979) and Turke (1984) suggested menstrual synchrony may be a strategy for increasing the investment of a male in female offspring. Frisch (1984) hypothesized that cycle synchrony would result in synchrony of pregnancies and lactation. Thus, a mother whose baby had died or who was capable of nursing two babies could feed a baby whose mother had died, and in the circumstances of high maternal and infant mortality this could be an important mechanism for survival of the species.

The assumption behind all these hypotheses is that menstrual synchrony reflects synchrony of ovulation or at least synchrony of the fertile period among cohabitating women, which has never been demonstrated (Kiltie 1982; Strassmann 1999). Another assumption is that menstrual bleedings occur regularly during women's reproductive period. While this may be true for most women in urbanized societies (i.e., with available contraceptives), according to Strassman's studies (1997, 1999) of Dogon women, a substantial portion of time during the reproductive years is devoted to pregnancies or nursing. As Strassmann reported from observations over two years, these women had very few menstrual cycles.

The goal of the present study is to determine whether menstrual synchrony can be found in a population of undergraduate women living together in student dormitories. If menstrual cycles synchronize as a consequence of women living together, then the mean differences in menstrual onsets among roommates at the beginning of the study should be greater than the mean differences at the end of the study. In addition, because synchrony is the matching of cycle onsets over time, once established it should persist. Biological factors which potentially impact the likelihood of synchrony, such as age, gynecological age (defined as the difference between actual age and the age at menarche), body mass, and menstrual cycle length, were either controlled or analyzed. Social factors previously reported to influence menstrual synchrony were also analyzed.

MATERIALS AND METHODS

Participants and Procedure

The study was conducted in 1998 in two student dormitories in Krakow, Poland, which were cohabited by women and men. The prospective participants were selected because of their similar social condition and their adjacent living arrangements. Both buildings had four floors, and on each floor there were 15 or 16 single, double, and triple rooms. Common kitchens and bathrooms connected some of the double and triple rooms. The rest of the rooms had separate bathrooms and kitchens. Rooms had an average area of 15 m^2 with standard furnishings including two or three beds.

Participants were college-age women living together in pairs or triples. They began living together late in September to early October when the Polish academic year begins. During the study period, they spent most of their time in the dormitories, occasionally traveling to their hometowns for weekends. A major term break of two weeks occurred from the middle of December to the beginning of January.

Every woman who lived in the dormitories was asked to participate, and 200 women agreed to take part. Out of 200 women, 116 (58% of the sample) returned correctly filled out questionnaires and menstrual calendars. These women lived in 28 double and 21 triple rooms. Owing to missing data or extreme irregularity of cycles (fewer than three cycles during the 6-month period), 17 women were dropped from the analysis, which resulted in a sample size of 99 women who lived in 18 double and 21 triple rooms. According to Wilson (1992), eliminating irregularly cycling women may produce a slight bias towards detecting synchrony. Ten of the women from 10 different rooms used oral contraceptives. Oral contraceptives regularize the cycles of users making it easier for the woman or women in a pair or triple to synchronize their cycles to that of the contraceptive user, but oral contraceptives also constrain women's ability to synchronize to other women's cycles. Therefore, the data were tested with and without the 10 units in which women used oral contraceptives. When the oral-contraceptive users were excluded, 13 pairs and 16 triples remained.

Women were asked to fill out a questionnaires and a menstrual calendar. The questionnaire was designed to collect demographic, menstrual, and social data. Demographic and menstrual questions were general and solicited information about date and place of birth, civil status, date of menarche, average length of menstrual cycle and its usual regularity, length of menstrual bleeding, use of hormonal contraceptives, body mass (self-reported), and lifestyle (physical activity and diet). Other questions were specific and concerned the women's social life, especially the frequency of activities shared with roommates. For example, women were asked how frequently during the week they performed activities with their roommates, such as preparing and consuming meals, studying, going out together, sharing clothing, and sleeping in the same room. Answers to frequency questions were categorized on a scale of 0 to 3: never = 0, one or two times per week = 1, three or four times per week = 2, and five or more times per week = 3. Women also answered questions concerning the amount of time spent during a day with roommates, studying, and with men. Answers were categorized into three categories on a scale of 1 to 3: 1–3 hours per day = 1, 4–6 hours per day = 2, more than 6 hours per day = 3. Questionnaires were distributed to participants twice during the study, in October and in January. Data on menstrual onset were collected for six consecutive months from September 1998 to the end of February 1999. Menstrual calendars were collected every month (except for the September calendars, which were collected together with those for October). The entire observation period lasted 181 days.

Data Analysis

Menstrual cycle onset differences between pairs and among triples were calculated based on menstrual calendars. Calendar dates were transformed into a single integer scale so that September 1 was day 1 of the study and February 28 was day 181 of the study. The initial differences in menstrual onsets in pairs of women were calculated using Wilson's method (Wilson 1992) and based on comparing the following absolute differences: $|A_1 - B_1|$, $|A_1 - B_2|$, and $|A_2 - B_1|$, where A and B are the women in a pair and 1 and 2 are the first and second menstrual onsets. The minimum absolute initial difference determined the initial onset difference for a pair.

In the case of triples, the initial difference in menstrual onsets were compared for three women by calculating seven mean-absolute onset differences (Jeffrey Schank, personal communication 2005):

$$(|A_1 - B_1| + |A_1 - C_1| + |B_1 - C_1|) / 3, (|A_1 - B_1| + |A_1 - C_2| + |B_1 - C_2|) / 3,$$
$$(|A_1 - B_2| + |A_1 - C_1| + |B_2 - C_1|) / 3, (|A_1 - B_2| + |A_1 - C_2| + |B_2 - C_2|) / 3,$$
$$(|A_2 - B_1| + |A_2 - C_1| + |B_1 - C_1|) / 3, (|A_2 - B_1| + |A_2 - C_2| + |B_1 - C_1|) / 3,$$
$$\text{and } (|A_2 - B_2| + |A_2 - C_1| + |B_2 - C_1|) / 3$$

where A, B, and C are the women in a triple and 1 and 2 are the first and second menstrual onsets. The minimum mean-absolute initial difference for a triple of women determined the initial onset difference for a triple.

The menstrual onset difference at the end of the study was calculated using the same method but used the last two menstrual onsets for each pair or triple rather than the first two onsets. Differences in menstrual onsets were also calculated at the midpoint of the study, which was day 90. The dates used for the middle onsets were those closest to day 90 of the study, and the differences were calculated using the same methods.

Other data from calendars and questionnaires were used to investigate the influence of social factors on possible menstrual synchrony. Questions about the amount of time spent together, frequency of sleeping in the same room, common preparation and eating of meals, studying, spending free time together, and exchanging clothes were used to create the Index of Women's Interaction (IWI). The IWI was the total number of points based on the values assigned to the different categories for each question. The maximum value of IWI was 41 and the minimum, 2. Values of IWI calculated on the basis of the first and second questionnaire did not differ significantly. The influence of women's social contacts with men was also evaluated by preparing the Index of Interactions with Men (IIM) in the same way as the IWI (summing the points based on answers to questions about the frequency and amount of time spent with males).

If a process of synchrony occurred between or among the women, then the absolute differences for pairs and triples should decrease from start to middle to end of the study. Tests for menstrual synchrony were conducted on the sample of 39 units (18 pairs and 21 triples) and involved comparison of the menstrual onset differences at the beginning, in the middle, and at the end of the study period using paired t-tests. Parametric tests were used because the distributions of initial, middle, and final menstrual onset differences were normal (all p-values not significant in Shapiro-Wilk test for normality). In addition, for synchrony to occur, the mean absolute onset differences for groups should be significantly below the expected absolute onset difference, which is approximately 7.5 days (see Schank 2000). If there are significant differences between the middle and end of the study, one-sample t-tests will be calculated to rule out regression to the mean effects (i.e., if the initial onset differences for the pairs and triples is greater than 7.5, regression to the mean would predict that subsequent differences would decrease to the expected value of 7.5).

RESULTS

The demographic, menstrual, and social characteristics of the women are provided in Table 1.

Analysis of Menstrual Onset Differences

Women did not synchronize their menstrual cycles. No statistically significant differences were found between initial and middle, middle and final, and initial and final menstrual onsets (Table 2) within all pairs and triples ($n = 39$). It should be noted that the inital onset differences for both pairs and triples were slightly greater than the expected difference of 7.5 days. Separate analyses were conducted to check for any differences in menstrual onsets between pairs ($n = 18$) and triples ($n = 21$). Average values of initial, middle, and final menstrual onsets difference were slightly but not significantly lower in the case of pairs relative to triples (Table 3).

Table 1. General Descriptive Statistics for the Study Sample ($n = 99$)

	Mean	s.d.
Age	22.3	1.50
Gynecological age	9.2	1.95
Cycle length (days)	30.5	4.56
Cycle irregularity (days)	6.2	5.02
Body mass (kg)	55.5	6.26
Time spent together during the day (hours)	6.1	2.41
Index of Women's Interactions (IWI)	12.0	4.24
Index of Interactions with Men (IIM)	4.3	3.82

Table 2. Menstrual Onset Differences at the Beginning, Midpoint, and End of the Study for All Women (n = 39). Differences between means were tested with matched pair t-test.

	Mean ± s.d.	t	p
Initial difference (days)	8.4 ± 4.07	1.672	0.10
Middle difference (days)	7.2 ± 4.55		
Middle difference (days)	7.2 ± 4.55	−0.388	0.70
Final difference (days)	7.5 ± 3.85		
Initial difference (days)	8.4 ± 4.07	−1.083	0.29
Final difference (days)	7.5 ± 3.85		

An additional analysis was conducted excluding units (pairs and triples) in which women used oral contraceptives. Women within these units (n = 25) did not differ significantly in terms of any characteristics except value of IIM (Table 4). Again, no statistically significant differences were found between units of users and non-users of oral contraceptives in initial, middle, and final menstrual onset difference (Table 5).

Analysis of Factors Influencing Menstrual Onset

The relationship between demographic, constitutional, and social factors and the difference in menstrual onsets at the beginning, in the middle, and at the end of the study was tested with multiple regression analysis on the sample of 99 women. Only two factors showed a statistically significant relationship with the initial menstrual onsets difference ($R^2 = 0.148, p < 0.05$) (Table 6). Cycle regularity was significantly positively related to the value of initial menstrual onsets difference ($\beta = -0.273, p < 0.05$) (Figure 1), whereas body mass was negatively related to the value of the initial menstrual onsets difference ($\beta = -0.228, p < 0.05$) (Figure 2). Menstrual onset differences in the midpoint and at the end of the study were not related to any of the factors.

Table 3. Menstrual Onset Differences at the Beginning, Midpoint, and End of the Study in Pairs (n = 18) and Triples (n = 21). Differences between means were tested with t-test for independent variables.

	Pairs (mean ± s.d.)	Triples (mean ± s.d.)	t	p
Initial difference (days)	8.3 ± 4.39	8.5 ± 3.89	−0.150	0.88
Middle difference (days)	6.9 ± 5.77	7.4 ± 3.32	−0.342	0.73
Final difference (days)	7.0 ± 5.03	7.9 ± 2.50	−0.697	0.49

Table 4. Differences in Characteristics of Nonusers ($n = 74$) and Users ($n = 25$) of Oral Contraceptives. Differences between means were tested with t-test for independent variables.

	Nonusers (mean ± s.d.)	Users (mean ± s.d.)
Age	22.3 ± 1.55	22.5 ± 1.37
Gynecological age	9.2 ± 1.92	9.2 ± 2.09
Cycle length (days)	30.6 ± 4.39	30.2 ± 5.12
Cycle irregularity (days)	6.0 ± 4.48	6.9 ± 6.41
Body mass (kg)	55.9 ± 6.70	54.4 ± 4.66
Time spent together during the day (hours)	6.2 ± 2.50	5.6 ± 2.08
Index of Women's Interactions (IWI)	12.1 ± 4.19	11.7 ± 4.47
Index of Interactions with Men (IIM)	3.8 ± 3.76*	5.8 ± 3.67*

* $p < 0.05$

DISCUSSION

As with the results of many recent studies (Jarett 1984; Trevathan et al. 1993; Weller and Weller 1995a 1995b, 1998; Wilson et al. 1991), no menstrual synchrony was found in pairs and triples of college-age women. This was one of the few studies since McClintock (1971) to analyze changes in mean absolute difference in menstrual onsets during the course of the study. This was also one of the first studies to examine menstrual synchrony in units larger than pairs (also see Yang and Schank 2006, in this issue).

Women within units (pairs and triples) did not synchronize their menstrual cycles. No statistically significant changes were found in any of the comparisons made, and the mean differences observed for all comparisons were close to the expected mean difference of 7.5 days.

These results are inconsistent with previous studies that reported menstrual synchrony in college-age women (Little et al. 1989; McClintock 1971; Quadagno et al. 1981; Weller and Weller 1992; Weller et al. 1995). There are at least two possible

Table 5. Menstrual Onset Differences at the Beginning, Midoint, and End of the Study in Nonusers ($n = 29$) and Users ($n = 10$) of Contraceptives. Differences between means were tested with t-test for independent variables.

	Nonusers (mean ± s.d.)	Users (mean ± s.d.)	p
Initial difference	8.6 ± 3.98	7.8 ± 4.50	0.62
Middle difference	7.2 ± 4.31	7.0 ± 5.45	0.88
Final difference	7.7 ± 3.96	6.7 ± 3.60	0.49

Table 6. Relationship between Constitutional and Social Factors and the Values of Initial Menstrual Onset Difference in the Sample of 99 Women. A multiple regression model was used with age, gynecological age, cycle length, cycle irregularity, body mass, IWI and IIM as factors.

	β	*p*
Age	–0.024	0.86
Gynecological age	–0.132	0.34
Cycle length (days)	–0.040	0.75
Cycle irregularity (days)	0.273	0.03
Body mass (kg)	–0.228	0.03
Index of Women's Interactions (IWI)	–0.070	0.50
Index of Interactions with Men (IIM)	–0.088	0.39

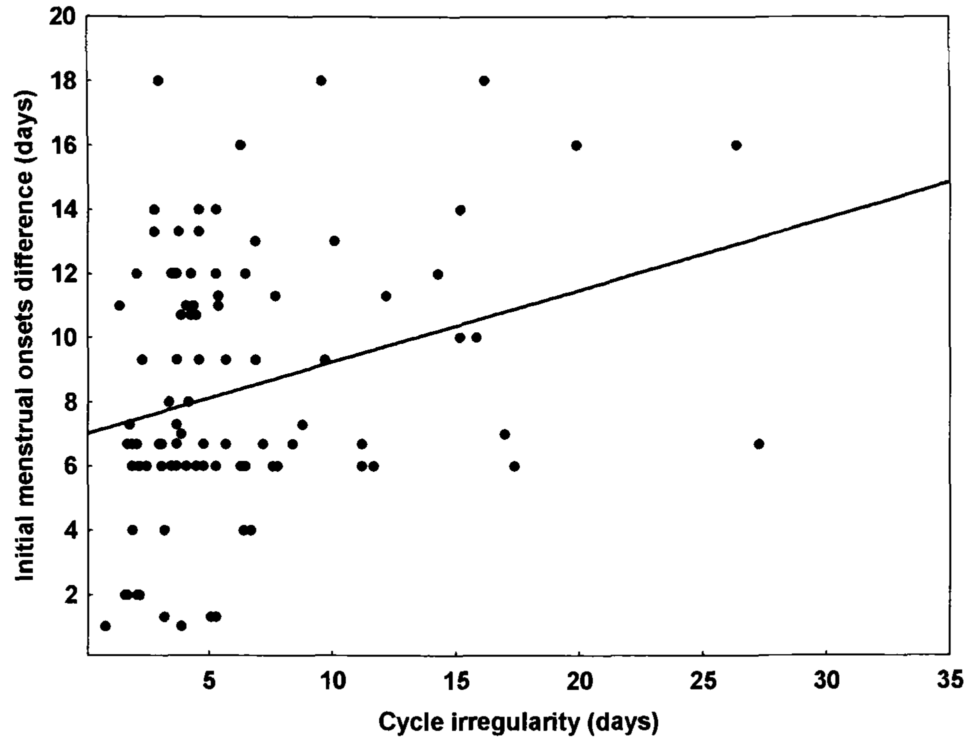
Initial menstrual onsets difference: $R^2 = 0.148$, $p < 0.05$

explanations for these contradictory findings. The first is that menstrual synchrony is highly dependent on very specific conditions in which women interact, such as close proximity of women and considerable time spent together (McClintock 1971; Weller and Weller 1993a). However, these conditions were fulfilled in the present study. Women lived in university dormitories, cohabitating in small double or triple rooms. On average they spent six hours a day studying, preparing, and eating meals together. They also spent almost every night sleeping in the same room. The sole major break during the period of the study lasted for less than two weeks, which is less than the break in the original study by McClintock (1971).

Another explanation for the failure to find synchrony is that previous reports of menstrual synchrony were simply "methodological artifacts" resulting from methodological errors (Schank 2000). Critiques of McClintock's (1971) study and subsequent studies by Weller and Weller uncovered several assumptions biasing the analyses of the data toward finding menstrual synchrony (Arden and Dye 1998; Schank 2000; Strassmann 1997; Wilson 1992). Methodology employed in the present study—examining the average difference in menstrual onsets for a long period of time—not only replicates a key feature of McClintock's study (1971) but also allows us to avoid observing "chance convergent" synchrony resulting from the convergence of the menstrual cycles over a short period of time (Arden and Dye 1998; Wilson 1992). This study and the statistical analyses used are free from these false assumptions.

Menstrual synchrony (if it exists) is a process that takes place over time and results in stable relationships of menstrual onsets among women. This implies that menstrual cycles must become less variable and converge on the same cycle length (e.g., 28 days). If there is cycle variability within and between women, synchrony cannot occur (Schank 2000). There is considerable variation in the cycle length in the groups of women who have participated in menstrual synchrony studies, and no

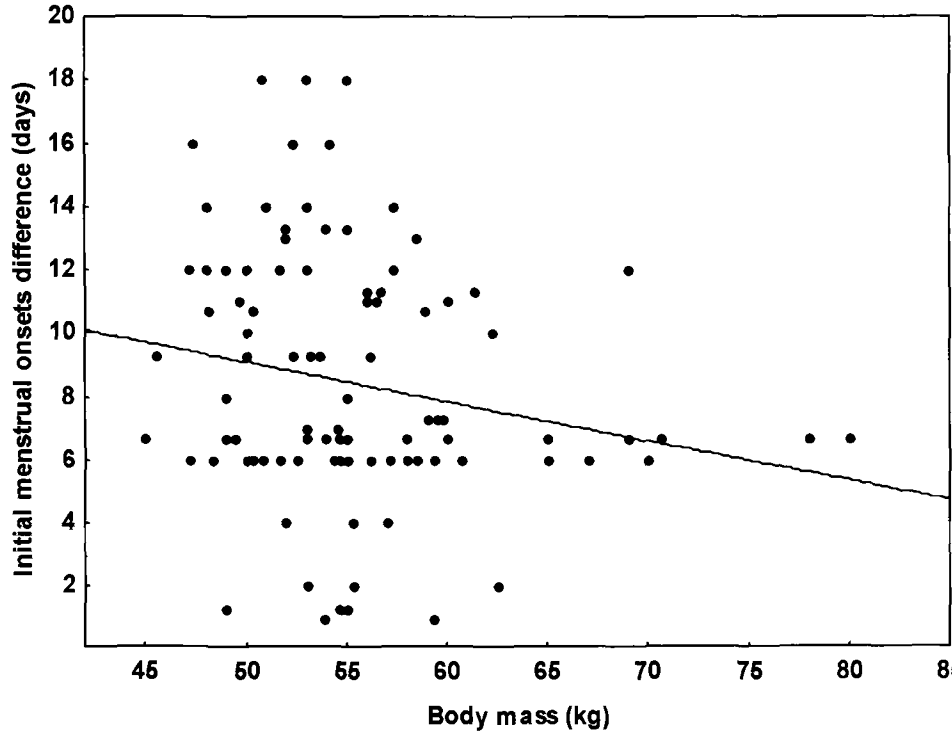
Figure 1. Relationship between initial menstrual onsets difference and cycle irregularity in the sample of 99 women ($\beta = 0.273, p < 0.05$)



study has shown a reduction in cycle variability. Cycle variability in these women probably depends on the varying characteristics of the women: for example, older or younger, in better or worse health, under psychosocial stress (Harlow and Ephross 1995). Indeed, the college-age women in the study sample showed great variety in menstrual cycle length, ranging from 23 to 54 days.

Although this study did not detect menstrual synchrony, it revealed factors related to menstrual onset differences. In particular, higher cycle irregularity was associated with a higher value of initial menstrual onset difference. Also, higher average body mass was associated with a lower initial menstrual onset difference. These two factors together explained about 15% of the variation in the initial menstrual onset difference. The relationship between cycle irregularity and initial menstrual onset difference seems to be intuitively obvious. Imagine a pair of women for whom mean cycle length was calculated. Woman A, with a low standard deviation of menstrual cycle length calculated with respect to the mean cycle length in pair AB, has a similar cycle length to woman B and therefore greater chance of a smaller menstrual onset difference. As discussed above, cycle irregularity both within and between the women is recognized as the main factor preventing menstrual synchrony from becoming established and persisting over time (Schank 2000; Weller

Figure 2. Relationship between initial menstrual onsets difference and body mass in the study sample of 99 women ($\beta = -0.228, p < 0.05$).



and Weller 1997). The incidence of irregular menstrual cycles is very frequent in young women whose hypothalamus-pituitary-gonadal axis function is not fully established (Treolar et al. 1967; Harlow and Ephross 1995). Surprisingly, very few observational studies (Weller and Weller 1992, 1993b; Wilson et al. 1991) included cycle irregularity as a factor potentially influencing this phenomenon, and only in one study was this fact found to be related to the occurrence of menstrual synchrony (Weller and Weller 1993a).

Less clear is the association between initial onset differences and a woman's average body mass. None of the previous studies investigated or demonstrated the influence of anthropometrical factors on menstrual synchrony. This is odd as anthropometrical factors are known to influence menstrual cycle quality. In particular body mass and body fat—factors describing the energetic status of woman—are correlated with levels of reproductive hormones, menstrual cycle regularity, and incidence of amenorrhea (Harlow and Ephross 1995; Potischman et al. 1996; Ziomkiewicz 2005). Thus, one might hypothesize that the negative relationship between body mass and menstrual onset difference is closely connected to the positive relationship between cycle irregularity and menstrual onset difference described above. Body mass in the present sample was self-estimated by the women. This could have produced a bias because women are known to underestimate their body mass (Engstrom et al. 2003). This bias, however, if similar for all women, would have only a minor influence on the presented relationship.

None of the social factors considered here were found to be related to the menstrual onset differences. The Index of Women Interaction (IWI) designed to investigate proximity level between women was unrelated to any of the menstrual onset differences. Since it has never been established how intense the social contact between roommates must be to mediate the effect of menstrual synchrony, this finding is difficult to interpret. Weller and Weller (1993a) hypothesize that social interactions (level of friendship, frequency of joint activities, and time of living together) can serve as the indicator of degree of exposure to potential pheromonal or olfactory stimulus affecting menstrual synchrony. Based on this hypothesis one can predict that women with higher intensity of social contacts should have lower menstrual onset difference. No such relationship was found in the present study, nor in several other studies of women living in close social proximity (Trevathan et al. 1993; Weller and Weller 1998).

In summary, this study did not detect menstrual synchrony in a group of college-age women cohabitating two university dormitories. Neither differences in the level of synchrony in pairs and triples nor any effect of oral contraception on the degree of synchrony was found. Initial menstrual onset differences were predicted by degree of cycle irregularity and average body mass of women. Middle and final menstrual onset difference was unrelated to any of the considered demographic, constitutional, or social factors. The negative results of this study add to the growing body of evidence undermining the existence of menstrual synchrony in human females. Menstrual synchrony has never been demonstrated in any unindustrialized, natural fertility, hunter-gatherer population (Strassmann 1997, 1999). Women in these populations spend most of their reproductive years pregnant or lactating, and menstruation is a rather sporadic event in their lives (Strassmann 1997). In such conditions menstrual synchrony, the establishment of which requires at least three consecutive menstrual cycles (McClinotck 1971), is unlikely to happen. Interestingly, it has also been theoretically demonstrated (Schank 2004) that in female Norway rats, estrous synchrony is a disadvantageous strategy increasing female-female competition. Although human mating systems are much less promiscuous than the rat mating system, a similar argument could be made for human females. Lack of convincing evolutionary explanation and the growing number of studies with negative results bring into question the existence of menstrual synchrony, which has been under intensive investigation for more than thirty years. Perhaps it is time to say goodbye to menstrual synchrony.

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