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On the frequency of intercourse around ovulation: evidence for biological influences

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BACKGROUND: Intercourse in mammals is often coordinated with ovulation, for example through fluctuations in libido or by the acceleration of ovulation with intercourse. Such coordination has not been established in humans. We explored this possibility by examining patterns of sexual intercourse in relation to ovulation. METHODS: Sixty-eight sexually active North Carolina women with either an intrauterine device or tubal ligation provided data for up to three menstrual cycles. These women collected daily urine specimens and kept daily diaries of intercourse and menstrual bleeding. Major estrogen and progesterone metabolites excreted in urine were used to identify the day of ovulation. The fertile days of the cycle were defined as the 6 consecutive days ending with ovulation. Women contributed a total of 171 ovulatory cycles. Menstrual bleeding days were excluded from analysis. RESULTS: The frequency of intercourse rose during the follicular phase, peaking at ovulation and declining abruptly thereafter. The 6 consecutive days with most frequent intercourse corresponded with the 6 fertile days of the menstrual cycle. Intercourse was 24% more frequent during the 6 fertile days than during the remaining non-bleeding days ($P < 0.001$). CONCLUSIONS: There apparently are biological factors that promote intercourse during a woman's 6 fertile days.

Key words: intercourse/ovulation

Introduction

There are 6 days in the menstrual cycle during which intercourse can produce pregnancy (Wilcox *et al*., 1995; Dunson *et al*., 1999). From an evolutionary perspective, any physiological mechanism that increases the frequency of intercourse during these 6 fertile days could have selective advantage by improving the chance of conception. Such mechanisms in other species include an increased sexual attractiveness or receptivity of the female during the fertile period. In addition, the probability of conception can be increased if intercourse stimulates ovulation. Such mechanisms have been conjectured to operate in humans (Joechle, 1975; Harvey, 1987; Regen, 1996) although with limited and indirect evidence.

If one or more of these mechanisms act in humans, we would expect to see more frequent intercourse during a woman's fertile days. We explored this possibility using prospectively collected data on intercourse and ovulation from sexually active women who were using effective non-hormonal methods of birth control.

Materials and methods

We recruited from the local community 39 women who were using an intrauterine device (IUD) and 31 women who had been sterilized by tubal ligation (Wilcox *et al*., 1987, 1988). The purpose of these studies was to assess hormone patterns in sexually active women of reproductive age. Women were eligible if they were in a stable sexual relationship and had no chronic illness or history of fertility problems. Participants kept daily diaries of intercourse and menstrual bleeding for up to three menstrual cycles. These women also collected daily first-morning urine specimens, which were stored frozen until assay. Details of the study protocol have been previously described (Wilcox *et al*., 1987, 1988). Most participants were white, college-educated, parous, and in their late twenties or early thirties (Table I). The study, carried out in 1983–1985, was approved by the Institutional Review Board of the National Institute of Environmental Health Sciences. All participants provided written informed consent. Women were highly cooperative, with diary data and urine samples missing for only 2% of days in the study.

Day of ovulation was identified through serial changes in daily urinary hormones (see below). A day of ovulation could not be determined for 5% of cycles, leaving 38 of the women with IUD (90 cycles) and 30 women with tubal ligation (81 cycles).

Table I. Characteristics of 68 North Carolina women with intrauterine device or tubal ligation

	%	(*n*)
Age (years)		
⩽25	12	(8)
26–30	35	(24)
31–35	49	(33)
⩾36	4	(3)
Education (years)		
⩽12	32	(22)
13–16	49	(33)
⩾17	19	(13)
Race		
White	99	(67)
Other	1	(1)
No. of previous pregnancies		
0	12	(8)
1	24	(16)
2	32	(22)
⩾3	32	(22)

We performed a supplemental analysis to address the hypothesis that intercourse is able to accelerate ovulation. Because this supplemental analysis would not be affected in any way by intentional timing of intercourse (such as could be expected among women who were trying to become pregnant), we were able to increase our sample size by including data from an additional group of 217 women (696 cycles) who were trying to conceive. These women were enrolled under the same protocol and have been extensively described (Wilcox *et al*., 1988, 1995).

Laboratory assays

We measured the daily excretion of estrone 3-glucuronide (a primary urinary metabolite of estradiol) and pregnanediol 3-glucuronide (a metabolite of progesterone) using competitive time-resolved fluoroimmunoassays (Kesner *et al*., 1994).

Defining the day of ovulation

The secretion of estrogen and progesterone undergoes rapid and distinctive changes around the time of ovulation. These changes are reflected in the urinary metabolites of these hormones. We had previously developed an algorithm to identify day of ovulation based on changes in the ratio of estrogen to progesterone metabolites throughout the several days before and after ovulation. We validated the algorithm against the surge of urinary LH (Baird *et al*., 1991, 1995). Subsequent studies have substantiated the relative precision of this method (Dunson *et al*., 2001). A recent French study (using ultrasound monitoring of follicular rupture as the gold standard) showed the algorithm to be as accurate as urinary LH in estimating the time of ovulation (Ecochard *et al*., 2001).

Statistical methods

All analyses of cycles were based on within-women averages rather than on total cycles. We included only non-bleeding days in our calculations because these couples reduced their frequency of intercourse during menstruation. We compared the frequency of intercourse during the 6 fertile days and during all other non-bleeding days, first by calculating the mean for each woman during those two time periods, and then by testing the difference with a Wilcoxon signed rank test. In estimating the distribution of ovulation across the days of the week, we calculated the proportion of ovulations occurring on each weekday for each woman, and then averaged these proportions across women.

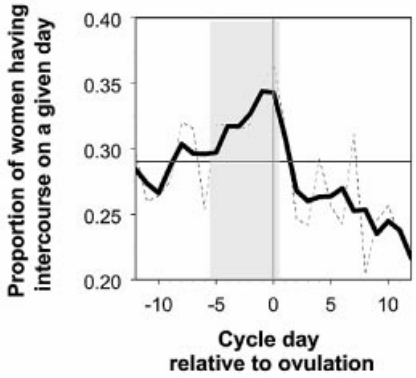

Figure 1. Proportion of contracepting women who have intercourse on a given day of the menstrual cycle, relative to the day of ovulation. The dashed line shows the mean values for each day, while the dark solid line shows the 3 day moving average (each data point representing the mid-point of a 3 day span). The 6 fertile days are shaded, with day of ovulation (O) marked by the thin vertical line. The horizontal line represents the overall mean frequency of intercourse on non-bleeding days (0.290). n = 68 women, 171 cycles.

Results

We have previously shown that there are 6 days of the menstrual cycle when intercourse can produce pregnancy (the 5 days before ovulation and the day of ovulation itself) (Wilcox *et al*., 1995). This 6 day fertile window has been confirmed in other studies (Dunson *et al*., 1999, 2002). In the present analysis we use the fertile window as the framework for exploring the frequency of intercourse. If biological mechanisms affect the timing of intercourse, we might expect to find that intercourse is most frequent during the fertile days, and less frequent before or after.

Figure 1 shows the mean daily frequency of intercourse in relation to day of ovulation. The dashed line shows raw daily means, while the dark solid line represents the 3 day moving average. The overall mean frequency of intercourse on non-bleeding days was 0.29 (shown by the horizontal line, equivalent to twice a week). The frequency of intercourse was above the mean for most of the follicular phase (before ovulation) and below the mean for most of the luteal phase. The 6 consecutive days of the cycle with the highest frequency of intercourse corresponded exactly with the 6 fertile days. The mean daily frequency of intercourse was 24% higher during the fertile days than during all other non-bleeding days (0.339 compared with 0.274, $P < 0.001$).

Within the 6 day fertile window, intercourse frequency reached its highest levels just before and on the day of ovulation. This pattern is similar to the underlying probability of conception given an act of intercourse; a clinical pregnancy is most likely to occur when intercourse takes place on the day before ovulation (Dunson *et al*., 1999).

Exploring biological mechanisms

The distinctive pattern of intercourse frequency across the menstrual cycle among women not trying to conceive suggests the presence of biological mechanisms that influence inter-

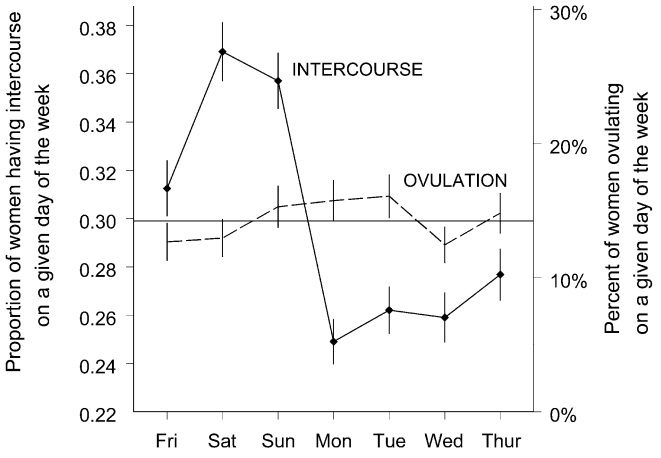

Figure 2. The frequency of intercourse and ovulation, by day of week. *y*-Axes are adjusted to equalize the dimensions of SEM for intercourse and ovulation (vertical bars represent 1 SEM). n = 285 women, 867 cycles.

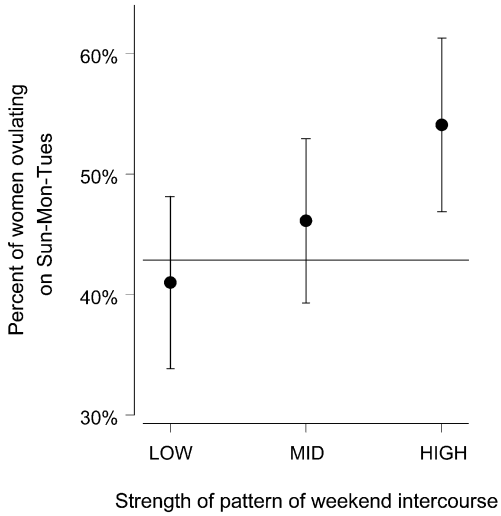

Figure 3. Estimated probability of ovulation on Sunday, Monday or Tuesday, for couples grouped according to the strength of their weekend pattern of intercourse (Friday, Saturday or Sunday). Horizontal line shows the null expectation of 3/7, or 43%. Vertical lines represent 95% confidence intervals. n = 285 women, 867 cycles.

course. One obvious hypothesis is an increase in male or female libido with the approach of ovulation, and a decline thereafter. We did not collect information on libido and so we cannot pursue this specific question.

The increasing frequency of intercourse just before ovulation could also represent an acceleration of ovulation stimulated by intercourse. In some mammals, intercourse can accelerate the rupture and luteinization of a mature ovarian follicle by triggering a release of GnRH that sets off the LH surge (Bakker and Baum, 2000). In humans, ovulation is thought to follow the LH surge by an average of 30 h (World Health Organization Task Force, 1980; Ecochard *et al*., 2001). If intercourse in humans could affect ovulation through the same neuronal pathway as in other mammals (assuming that the time from the triggering event of intercourse to the LH surge is no more than a few hours), we would expect ovulation to follow the triggering intercourse by 1–2 days.

It is inherently difficult in observational data to know whether ovulation is the cause—or the result—of the high frequency of intercourse just before ovulation. We addressed this question by taking advantage of a strong cultural pattern of intercourse. Couples in our study were most likely to have intercourse on the weekend (Friday, Saturday or Sunday). Ovulation, in contrast, presumably occurs without regard to day of the week. If intercourse were able to accelerate ovulation, then we would expect weekend intercourse to produce a corresponding increase of ovulation 1–2 days later. In order to address this question, we enlarged our sample size by adding a supplemental sample of 217 women who were trying to become pregnant. This provided a total of 285 women and 867 cycles.

Figure 2 shows the frequency of intercourse and ovulation by day of week. The peak of intercourse on Friday–Saturday–Sunday is followed by a small rise in the frequency of ovulation on Sunday–Monday–Tuesday (47% of all ovulations, compared with an expected 3/7 or 43%). This association is too weak to confirm the hypothesis. However, it did suggest a further test.

The weekend pattern of intercourse was not present in all couples. Some had no weekend preference at all (for example, those having daily intercourse). Data from such couples would dilute the hypothesized pattern of ovulation. We therefore divided couples into three groups depending on the strength of their weekend pattern. Specifically, we ranked couples according to the ratio of their intercourse on Friday through Sunday compared with the rest of the week, and divided them into three groups. Couples in the highest third had twice as much intercourse on weekends as on weekdays, while couples in the lowest third had no weekend preference.

Figure 3 shows the pattern of ovulation in these three groups. Among couples with no pattern of weekend intercourse, the estimated probability of ovulation on Sunday–Monday–Tuesday was 41% (slightly less than the null expectation of 43%). The percentage of post-weekend ovulations rose to 46% among couples with moderate patterns of weekend intercourse, and reached 54% for couples with the strongest pattern of weekend intercourse (test for trend, $P < 0.01$). This trend was similar for the two study groups (those using effective birth control and those trying to conceive).

Discussion

There are surprisingly few data on the natural pattern of human intercourse across the menstrual cycle. Most previous studies have been based on small samples with indirect markers of ovulation. For example, a 1978 study of 23 women estimated ovulation by counting backward from the onset of the next menses (Adams *et al*., 1978). While that study found an apparent increase in intercourse around ovulation, others have not. The most recent review (published in 1982) concluded there was 'little to support a mid-cycle or peri-ovulatory peak' in sexual activity (Sanders and Bancroft, 1982). A subsequent

study of 25 African women has suggested an increased intercourse frequency on the day before the urinary LH peak (Hedricks *et al*., 1987).

We analysed intercourse data from 68 women who were using highly effective non-hormonal methods of birth control (either IUD or tubal ligation). These women had no reason to modify the timing of their intercourse in relation to their fertile days. Their frequency of intercourse was above the mean during the follicular phase, peaking during the 6 fertile days of the cycle, and then falling to relatively low levels during the luteal phase (Figure 1). This pattern is unlikely to be due to chance. What biological mechanisms might explain it?

There are at least three possible contributors to this pattern. One is cyclic fluctuation in women's libido. Dennerstein *et al*. (1994) conducted a study of female libido in which 168 women kept daily diaries and collected daily urine samples for later identification of ovulation. Self-reported 'sexual interest' increased in the days before ovulation and declined afterward. These changes in women's libido are consistent with the pattern of intercourse in our data.

Another factor in this intercourse pattern could be a cyclic increase in the woman's sexual attractiveness. An increase in intercourse initiated by the male partner has been reported to occur around ovulation (Harvey, 1987). This could reflect the man's response to subtle behavioural cues from the woman, or perhaps to the woman's production of cycle-dependent pheromones. Support for a pheromone hypothesis is found in a recent clinical trial of a commercially produced pheromone (McCoy and Pitino, 2002). Women using the active product reported more frequent sexual approaches by their male partner. Taken together, these two lines of evidence raise the possibility that cycle-specific influences on male libido contribute to the cyclic pattern of intercourse.

A third possibility is the acceleration of ovulation by intercourse. How plausible is such a mechanism in humans? While the possibility has been raised (Clark and Zarrow, 1971; Joechle, 1975) it has been regarded with skepticism (Vollman, 1970). Species are usually thought to be either reflex or spontaneous ovulators, with ovulation in humans being spontaneous. However, experiments on rodents have suggested that even among spontaneous ovulators, the neural circuitry needed for intercourse to stimulate ovulation may be present (Bakker and Bau, 2000).

Our observation of a rise in ovulation following the weekend peak of intercourse supports the possibility of accelerated ovulation in humans. However, this could also reflect weekend changes in other factors (perhaps sleep patterns, exercise, or stress) that might affect ovulation. A simple randomized trial could test the hypothesis definitively. Such a randomized trial could be conducted among volunteer couples using non-hormonal methods of birth control. Couples would have to agree to ultrasound surveillance of follicle development and then to the random assignment of intercourse (or no intercourse) from the time the dominant follicle approaches its maximum size until after ovulation. A cross-over design in successive cycles would provide statistical power with relatively modest sample size.

In conclusion, our data from 68 women using effective methods of birth control show that intercourse is most likely to occur during the 6 fertile days of the menstrual cycle. It is remarkable that the biological forces shaping this intimate aspect of human behaviour have gone largely unrecognized, perhaps because the effect is modest in absolute terms. For couples who wish to conceive, these biological mechanisms act as a silent partner that facilitates the optimum timing of intercourse. Women who do not wish to become pregnant should be informed that occasional unprotected intercourse may be more risky than chance alone would predict (Wilcox *et al*., 2001).

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