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Coitus-Induced Ovulation and Its Implications for Estimates of Some Reproductive Parameters

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Abstract. It is estimated here that, at the time of conception, the mean coital rate of young women who subsequently bear DZ twins is about 6% higher than that of the general population of young married women. This differential seems too small to account wholly for the greater promptness in conceiving DZ twins. Accordingly, it is suggested that coital rate is associated with DZ twinning in two ways. The major link seems to be indirect and mediated by erotic response which causes an increase in gonadotrophin levels and thus in double ovulation. In a minority of cases, frequent coitus may give rise to DZ twins via superfecundation, but it seems that, in human beings, the corpus luteum of one ovum will usually inhibit fertilization of any further ova after a short interval. The evidence presented here, though indirect, seems to suggest that, under particularly erotic conditions, double ovulation is sometimes induced. It seems reasonable to infer that coitus also occasionally provokes or accelerates single ovulations, thus impugning some rhythm methods of contraception. But there seems no very good evidence that rape induces ovulation. Some notes are added on the implications of induced ovulation for estimates of fecundability and of the length of the fertile period.

Key words: Coitus, Ovulation, Twinning, Fecundability, Gonadotrophins, Rape, Contraception

INTRODUCTION

I have noted [13,17] that, after age and parity have been taken into account, the circumstances under which women conceive DZ twins seem to be the circumstances under which they have high coital rates. What causal mechanism can underlie this association?

Autopsy data [41] and pathological examination [5] suggest that double ovulation is much more frequent than the incidence of DZ twins among maternities. Moreover, the

two ova are not always released simultaneously. So, unless the corpus luteum of the first ovum were always to inhibit fertilization of the second if it arrived after a short interval, coital rate would necessarily be positively related to the probability of DZ twin conception. The question is whether the corpus luteum does have this effect.

In assessing the relationship between coital rate and DZ twinning, two lines of evidence have been discussed: 1) legitimate and illegitimate DZ twinning rates in young women, and 2) the promptness of conception of DZ twin pregnancies. These will each now be considered.

1. The Dizygotic Twinning Rates in Young Women

Among women aged less than 20, the legitimate DZ twinning rate was consistently and significantly higher than the illegitimate DZ twinning rate in England & Wales 1938-78 [17]. Now, DZ twinning rates are in principle dependent on four parameters: coital rate, probability of conception, probability of spontaneous abortion, and probability of double ovulation [15]. Coital rates of young unmarried women are substantially lower than those of young married women: so, since there seemed no reason to suppose variability in any of the other parameters with legitimacy, I inferred that coital rate was the parameter responsible for the differential with legitimacy in DZ twinning rates in young women.

2. The Promptness of Dizygotic Twin Conception

There can be no doubt that immediately after marriage [6,36] and after wars [3,32] women take less time to conceive DZ twin pregnancies than singleton pregnancies. I had suggested that this too was because of higher coital rates. I assumed in both cases that the role of coital rate was via superfecundation. Let us call this the Superfecundation Hypothesis.

ALLEN'S HYPOTHESIS

Allen has responded to this with the alternative hypothesis that emotional excitement may sometime provoke double ovulation in women. He wrote: "It seems as if the marriage event itself promotes twinning; and so does return of husbands from war, or an illicit love affair" [1]. Now, as noted above, the illegitimate births to women under 20 have *lower* DZ twinning rates than the legitimate ones. Allen reconciles this with his hypothesis thus: "While I suppose that psychological sexual arousal is generally more intense in connection with extramarital coitus than in marital relations, the frequency of sexual arousal is probably correlated somewhat with the frequency of coitus. Since ovulation does not ordinarily coincide with coitus in humans, psychological state during coitus would not be so important as the average state around the time of ovulation" [2]. Allen supports his case by offering results derived from a model. The model relates the possible variation in DZ twinning rates to variation in sperm quality consequent on varying coital rates. Allen concludes that such a model could not account for the variation in DZ twinning with coital rates suggested by the data.

I wish to make two comments on these papers of Allen: first on the model, and second on his attempt to reconcile his hypothesis with the low DZ twinning rate in illegitimate infants born to young women.

- 1) Allen's model embodies the assumption that double fertilization is a single event rather than two discrete events separated sometimes by an appreciable interval of time. Yet that assumption is the point at issue: though the ovulations may be separated by an interval of time, we do not know whether the corpus luteum of the first ovum inhibits the second from fertilization. The model offers no insight into that problem.
- 2) To account for the low DZ twinning rate in illegitimate pregnancies to young women, Allen invokes the average psychological level of excitement around ovulation instead of at coitus. He claims this is reasonable because ovulation does not ordinarily coincide with coitus in humans. I am not clear that the argument is valid: the subjects of discussion are the results of fruitful cycles (when ovulation and coitus *do* coincide). So it is irrelevant whether emotional excitement fluctuates with peaks at coition.

In the rest of this note, I want to indicate why I nevertheless think there is some truth in Allen's hypothesis, and how it may be reformulated to accommodate the difficulties posed by the DZ twinning rates in young women.

A TEST OF THE SUPERFECUNDATION HYPOTHESIS

I have noted that in two different sets of circumstances, a doubling of coital rate seems to be associated with a 25% increase in DZ twinning rates [17]. The two contrasts are of circumstances preceding a) illegitimate vs legitimate conceptions in young women, and b) conceptions in the first months of marriage vs those occurring later in marriage.

It seems reasonable to estimate from these observations the mean difference in coital rates between young DZ twin bearers and comparable singleton bearers. Then one may examine whether this estimated difference can account for the known difference in conception waits leading respectively to twin and singleton conceptions.

It may be shown that if coital rate and DZ twinning probability have a joint normal distribution, and if doubling coital rate is associated with a 25% increase in DZ twinning probability, then

$$\bar{C}_{dz} = \bar{C} + \left(\frac{1}{4} \sigma_c^2 / \bar{C} \right)$$

where

\bar{C}_{dz} is the mean coital rate of DZ twin bearers,

\bar{C} is the mean coital rate of the general population, and

σ_c is the standard deviation of the coital rates in the general population.

Now, the mean coital rate of young newly-married women is about 15 per month [22]. The coefficient of variation (SD/mean) of reported coital rates (of samples of couples homogeneous for various demographic variables) is about 2/3 regardless of the mean. As I have shown that, when corrected for reporting error, the true value of this coefficient must be of the order of 1/2 [18]. Hence at conception, newly-married DZ twin bearers have a mean coital rate that exceeds the overall mean by about $1/4 \cdot 1/2 \cdot 7^{1/2}$, viz, about one coition per month or about 6%.

I have noted [12] that if the fertile period (that part of the menstrual cycle during which conception *can* occur) is comparatively short, then fecundability (the probability

of conceiving in a month at risk) is roughly proportional to coital rate. Moreover, it seems [16] that the fertile period *is* short, and this view is substantiated by Royston's estimates of the mean fertilizing lifetimes of sperm and ovum at respectively 1.5 and 0.7 days [38]. Hence, fecundability is roughly proportional to coital rate. Allen & Schachter [3] suggested that when U.S. servicemen returned home after the Second World War, the mean conception wait to a DZ twin conception was only about 60% that to a singleton conception. This estimate is based on the difference in time between the subsequent peaks in twin births and in singleton births in 1946. As such, the estimate is subject to reservations concerning sampling error and exposure to contraception of the twin mothers and singleton mothers. However, it seems fair to infer that the greater promptness in conceiving DZ twins cannot be wholly accounted for by so small a differential in coital rates as that estimated above. A similar conclusion might be drawn from Bulmer's data relating twin births to duration of marriage [6]. And these conclusions would be strengthened rather than weakened if it were to turn out that – as will be argued – ovulation is occasionally induced by coitus (for then the length of the fertile period would be greater, and the association between coital rate and fecundability would be weaker).

So, though DZ twin bearers almost certainly have higher coital rates than other women, these higher coital rates seem unable wholly to explain their greater promptness in conceiving. It follows that some parameter as well as (or other than) coital rate must be responsible for the prompt DZ conceptions. It seems unlikely that legitimacy in young women should directly influence spontaneous abortion rates, or the probability of fertilization, given that coitus has occurred. Hence, it seems likely that the parameter at issue is double ovulation, thus vindicating Allen's suggestion, and impugning my previous scepticism [21] on the point. Indeed, it seems that the present evidence is among the strongest so far adduced for coitus-induced ovulation.

In short, something associated with the first months of marriage or with a husband's homecoming after an absence seems to cause higher rates of double ovulation. So what about the effects of an illicit affair? In particular why should the illegitimate infants born to young women have low DZ twinning rates?

It has been hypothesised [30] that double ovulation is at least partially controlled by maternal gonadotrophin levels, and there is a considerable body of support for the hypothesis. So, if subjective experience affects DZ twinning rates, it presumably does so via gonadotrophin levels. The problem is to specify the subjective experience. What is common to the experience of wives of returning servicemen and of newly-married women, but not shared by young women involved in an illicit affair? One answer – but not the one we are seeking – is high coital rates. Possibly a further answer will emerge from a brief review of the effects of various sorts of subjective experience on gonadotrophin levels. However, interpretation of research in this field is not easy.

In the first place, coitus itself seems to cause no appreciable rise in gonadotrophin levels in women [8,27,31,40]. In contrast to the rather general agreement on this point, it has been reported that erotic arousal (in the absence of coitus) *does* cause a rise in gonadotrophin levels in men [24,25] and women [26]. Furthermore, it seems that surgery is associated with low gonadotrophin levels in women [39,42] and men [7]. Lastly, La Ferla et al [25] explicitly draw the inference that anxiety reduces gonadotrophin levels. This latter suggestion may throw light on the present problem. It seems reasonable to distinguish between erotic and emotional response, and to suggest that it is the erotic rather than the emotional component which is associated with gonadotrophin levels.

Now, illicit sexual intercourse is, for many young women, an occasion of emotional turmoil but (perhaps because of anxiety) erotic deficit. Accordingly, it seems reasonable to suggest that their gonadotrophin levels may be low and that the low DZ twinning rates among their infants is thus explained.

To summarise, it is suggested here that intense erotic experience sometimes induces double ovulation, and that the frequent absence of such experience in the sexual encounters of young unmarried women explains the low DZ twinning rates among their infants. If it were true, this reformulation of Allen's hypothesis would seem to explain most (if not all) of the association between coital rates and DZ twinning.

Three questions arise:

- 1) Apart from occasionally inducing double ovulation, does frequent coition play any further role in the etiology of DZ twins via the process of superfecundation?
- 2) Are DZ twin bearers more fecund than other women?
- 3) Does coitus or its neuroendocrine concomitants ever provoke or accelerate single ovulations?

Attempts to answer these questions will now be made.

1. DZ Twinning and Superfecundation

Since double ovulation is not always simultaneous, and since the first ovum may be fertilized by a relatively aged sperm, it follows that the second cannot be fertilized except by the product of another coition. It seems highly likely that sooner or later the corpus luteum of the first ovum will inhibit fertilization of the second, but this process can hardly be instantaneous. So, in principle, superfecundation with fertilization at different times must occasionally occur. And such a phenomenon would necessarily be related positively to coital rate.

Now, the estimated difference in coital rate between DZ twin-bearers and singleton-bearers is not large: moreover, on the basis of the argument above, one might suppose that part at least of that difference is associated with inducing double ovulation rather than facilitating superfecundation. So, the extent to which DZ twinning is augmented by superfecundation seems not to be large.

2. The Fecundity of DZ Twin-Bearers

It seems that, contrary to Allen [2], one might judge that DZ twin-bearers are, in general, more fecund than other women. I have noted above that DZ twinning is dependent on four parameters: coital rate, probability of fertilization given that coitus has occurred at the optimum time, probability of spontaneous abortion, and probability of double ovulation. Now, I have shown that when the probability of double ovulation is held constant, the probability of bearing a pair of DZ twins is positively related to fecundability [19]. This is because the first three of the above parameters are components of fecundability. Moreover, they vary substantially from woman to woman, and they remain fairly stable within a given woman. So, women ascertained by bearing a pair of DZ twins are, on the average, selected for fecundability as well as for double ovulation.

The magnitude of the overall reproductive superiority of DZ twin-bearers is not known but is probably not great. Taking the two parameters to be roughly proportional [20], fecundability is presumably augmented by about 6% in respect of the higher coital rate: and one might suppose that the further selection for probability of fertilization

and against spontaneous abortion will boost fecundability by a few further percentage points.

It would perhaps be best measured by contrasting the conception waits to *n*th-born singletons in women who a) subsequently bear DZ twins, and b) never have DZ twins. The design of such research would need attention, since:

- 1) Control is presumably needed for the final number of maternities;
- 2) Prenuptially pregnant women would have to be excluded;
- 3) The waits would be of non-contraception preceding conception;
- 4) Women who had been treated for subfertility would have to be excluded (to eliminate those whose twins were caused by the treatment).

3. Does Coitus Ever Provoke or Accelerate Single Ovulations?

I have suggested that erotic experience may induce double ovulation. If this is correct, it would seem highly probable that it would at least sometimes accelerate single ovulations by a day or so. Parkes [34] suggested that more negative subjective experience (eg, the fear or anger accompanying rape) might also produce reflex ovulation. This is supported by the data reviewed rather enthusiastically by Jochle [23]. He considered two sorts of data, viz, pregnancies following rape, and those following short home leaves of German servicemen during the First World War. The point about both is that the variance of cycle day of conception is substantially greater than that of cycle day of ovulation in normally cycling women. If one were satisfied by the quality of these data, one would infer that ovulation is sometime provoked by coitus or by its emotional concomitants. But in neither case does the evidence seem watertight:

- a) A rape victim who was already pregnant might take the opportunity to assign paternity to the offender if the real father were unknown, unacceptable or unwilling (and he might be unwilling because of genuine uncertainty concerning paternity or for other motives, eg, a disinclination to be publicly associated with a rape victim);
- b) An adulterous wife might claim falsely that she conceived during her husband's leave.

Both sorts of false reporting would tend to produce a spuriously large variance of cycle day of conception.

It is only fair to Jochle to note that he considered 100 cases of rape which he judged to be specially well established, and he found a large variance in reported cycle day of conception among these too. However, there is a curious feature about these data which Parkes [35] noted, namely, that a disproportionate number of the rapes were alleged to have occurred during menstruation. Possibly some such allegations were false, being made by women who wished to gain circumstantial leeway in establishing that they were not pregnant at the time of the offence.

Another potential source of information on the possibility of coitus-induced ovulation is the proportion of rapes which result in pregnancy. The difficulty with this sort of data is that a woman who finds herself pregnant following a rape is presumably more likely to report it. This objection might be met by ascertaining only cases reported before the pregnancy status could have been checked. Parkes [34] judged that there is a high conception rate in rape. However, some estimates of this parameter seem remarkably low [11] even bearing in mind that apparently only a minority of rape victims are inseminated [10]. In some centres, rape victims are routinely given postcoital contraception [29]

and when low rates are reported, one may wonder whether this is the reason.

It seems fair to suggest that these data present more questions than they answer. I think it would be unwise to conclude anything more definite than that they do not rule out the possibility that in favourable circumstances ovulation may sometimes be induced by sexual behaviour. It is not clear whether this applies to rape as well as to circumstances more conventionally thought to favour erotic arousal. There are three reasons for speculating that rape has no such effect; each is weak, but their cumulative effect may carry some weight:

- a) An evolutionary biologist might wonder whether there is any reproductive advantage in additional fertility following rape;
- b) It does not seem to have been suggested that rape is associated with the conception of DZ twins – as presumably should be the case if rape were to induce ovulation;
- c) If rape were to provoke ovulation, why should the DZ twinning rate in the offspring of young unmarried women be low? After all, if it is correct that high levels of gonadotrophin are associated with erotic experience [26] and low levels with anxiety [25] then it seems reasonable to expect that rape would not be particularly associated with high levels of gonadotrophin and hence with provoked ovulation.

COMMENT

The present note has rather wide implications:

- 1) It offers implicit support for the finding of La Ferla et al [26] that erotic stimuli cause a rise in gonadotrophin levels in women. This in turn suggest that coitus may occasionally provoke single (as well as double) ovulation, thus impugning some rhythm methods of contraception.
- 2) It also suggests that in human beings, multiple conceptions are not usually much spaced out in time, and that the corpus luteum of one ovum usually inhibits the production or fertilization of others after a short interval.
- 3) Lastly, some work on the biometry of the human reproductive process has been based on the assumption that coitus and ovulation are unrelated in time. It may be worth illustrating the relevance of induced ovulation to this work.

1. The Duration of the Fertile Period

Estimates of this parameter are required by those who wish to conceive and those who wish to avoid conception using a rhythm method. Now, if ovulation and coitus were unrelated, then the fertile period may be regarded as the sum of the viable lives of the ovum and of the sperm less any time required for capacitation. And it would seem that an estimate of the duration of the fertile period based on this reasoning would be comparatively short, say two or three days [16,38]. It seems likely that, as Parkes [35] suggested, if provoked ovulation does occur, then ovulation is merely accelerated by a day or so (rather than accelerated by several days or that a second fertilizable ovum is released some days after the first has been released). This conclusion is supported by the calculation that the coefficients of variation of fecundability and of coital rates are roughly equal, and that therefore the fertile period cannot be very lengthy [20]. So it seems that in spite of occasional provoked ovulations, the fertile period is nevertheless typically rather short, say of the order of three days.

2. The Relationship Between Coital Rate and Fecundability

I have noted [12] that if the fertile period is comparatively brief, then the probability of coitus occurring during the fertile period (and hence fecundability) is roughly proportional to coital rate. Inspection of the table in Potter [37] confirms this rough proportionality if the fertile period is as brief as suggested above. It should be noted that work seeming to indicate a comparatively lengthy fertile period and impugning this proportionality [4] is itself dependent on the highly questionable assumption that the BBT test is an accurate index of ovulation.

Elsewhere I have elaborated on the suggestion that coital rate and fecundability are roughly proportional [20]. The shape of the distribution between couples of fecundability is unknown: but if the proportionality above obtains, then it could be inferred from that of coital rates (which is apparently of the negative binomial form). It seems unlikely that the existence of provoked ovulation (to the extent envisaged here) much affects this conclusion.

3. Estimates of Fecundability

The mean and variance of fecundability following marriage may be estimated by making a mathematical fit to the distribution of the interval from marriage to first conception in non contracepting women who were not pregnant at marriage. Majumdar and Sheps [28] found it difficult to make such a fit: one reason for this difficulty was the large number of women claiming to conceive in the first month of marriage. Almost certainly some such claims were false, being made by women already pregnant at marriage [14]. But a proportion of the remainder may be accounted for by provoked ovulation. During the first year of marriage, fecundability presumably declines rapidly, both because of the decline in coital rates [22] and because of the diminishing chance of provoked ovulation.

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