

Symmetry and ovulation in women

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Women have cryptic ovulation, and self-observation methods of determining the timing of ovulation, such as monitoring cervical mucus symptoms or recording basal body temperature, are not reliable. It has recently become apparent that the symmetry of paired soft tissue traits, such as breast size and digit length, changes across the menstrual cycle. This paper presents evidence that symmetry in four paired soft tissue traits showed a marked increase on the day of ovulation. The difference (i.e. the asymmetry) between the size of the left and right trait in ears, 3rd, 4th and 5th digits was measured. The timing of ovulation was confirmed by real-time pelvic ultrasonography and trait measurements were made without knowledge of scan results. Asymmetry was lowest on the day of ovulation (day 0), decreasing by about 30% from day -1, and significant within-subjects changes occurred from days -2 to day -1, and day -1 to day 0. The practical and evolutionary implications of these findings are discussed.

Key words: ovulation/symmetry

Introduction

In primates most females show cues to ovulation (Sillen-Tullberg and Møller, 1993). However, among humans it is generally considered that ovulation is not perceived consciously by others nor is it usually perceived by self (Burley, 1979). This raises important evolutionary questions concerning why oestrus has been lost in women but it also poses practical problems relating to fertility and contraception. For example, conception control by avoidance of intercourse requires abstinence for at least 10 days of a typical 28 day cycle (Burley, 1979). Natural family planning requires self-observation of cervical mucus symptoms or recording basal body temperature. The latter has limitations as an indicator of day of ovulation as the temperature increase occurs after the ovulation event. A study of natural conceptual cycles (France *et al.*, 1992) used these plus pre-ovulatory luteinizing hormone (LH) surge as ovulation indices, and in only six (9.2%) cycles did these three markers identify the same day.

In humans, many traits such as ear size, digit length and

breast size are composed partly or entirely of soft tissue, and these traits can change their dimensions during the menstrual cycle in women. It has recently been shown that symmetry of such traits also shows changes across the cycle (Manning *et al.*, 1996). Symmetry is measured by subtracting the length of the right side of a trait (such as ear length) from the length of the left side. Perfect symmetry, i.e. a score of zero, may be found but more usually individuals are bigger on the left or right side and this gives an asymmetry score for that particular trait in that individual (Manning, 1995). Asymmetry is generally low at the beginning of menstruation and rises to a peak at about day 24 and then reduces until menstruation begins. In mid-cycle, however, there is a very marked decrease in asymmetry which occurs over a period of 24 h. It has been suggested that the latter may indicate ovulation (Manning *et al.*, 1996). The purpose of this work was to investigate this proposed relationship by examining the correlation between asymmetry and ovulation across mid-cycle.

Materials and methods

Thirty healthy female volunteers were included in the study and all gave written informed consent. All subjects were under 44 years of age (mean = 29.27, SE = 1.16, range 19–44 years) with a normal menstrual history and typical cycles of approximately 28 days. None were taking oral contraception. Four paired traits (ear length and the length of the third, fourth and fifth digits) were measured. These traits may be measured with a high degree of repeatability, they are easily and reliably measured and accessible, and they also show fluctuating asymmetry, that is, the mean asymmetry is zero and the distribution of the asymmetries around the mean is parametric (Manning, 1995; Manning *et al.*, 1996). Subjects were measured on days 12–16 of their cycle using Vernier callipers measuring to 0.05 mm (Figure 1). Timing of the measurements was standardized on each day post-ultrasound for 24 volunteers, but three had some unavoidable variation in timing due to work commitments. Asymmetry was calculated as the difference between the left and right trait (L–R). Asymmetries were small, i.e. of the order of 2% of the total length of traits; therefore in order to minimize measurement error, all traits were measured twice and mean asymmetries were calculated for all characters.

Ovulation was determined by serial trans-abdominal real-time ultrasonography (Manning *et al.*, 1982) by scanning each subject on days 12–16 of her cycle. The uterus, ovaries and adnexae were examined and the uterine endometrium and any ovarian follicular development was documented. Ovulation was confirmed when there was disappearance, collapse or crenation of a dominant follicle. The presence or absence of free pelvic fluid which may be associated with ovulation was noted.

Calliper measurements were made without knowledge of the ultrasound scan results. If the measurements indicated that the subject

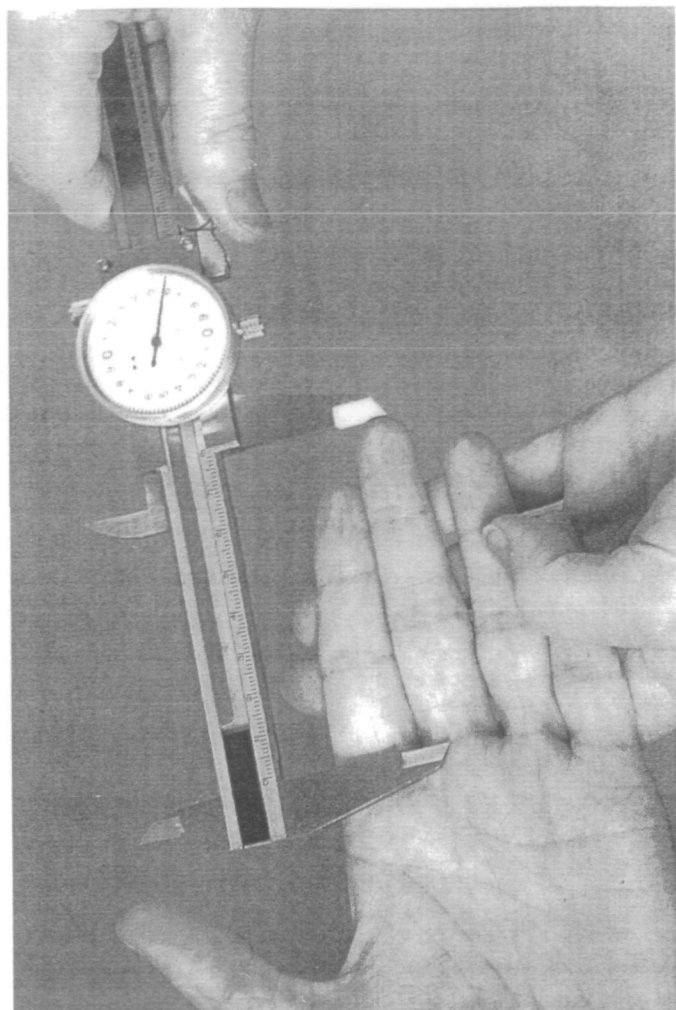


Figure 1. Measurement of third digit using Vernier calipers.

had not ovulated by day 16, and follicular development was continuing normally, ultrasonography and calliper measurements were continued until ovulation occurred.

Results

Ovulation was observed in 27 subjects (mean day in cycle = 16.22, SE = 0.487, range 13–23) and occurred twice in two subjects. Of the remainder, two did not ovulate (one presented with bleeding on day 16) and intestinal gas prevented confirmation of ovulation in the third subject. Mean asymmetries were similar for each trait (ears, mean = 0.84 mm, SE = 0.14; third digit, mean = 0.73, SE = 0.11; fourth digit, mean = 0.89, SE = 0.113; fifth digit, mean = 1.11, SE = 0.19). Summing asymmetries across the traits would therefore result in an overall asymmetry score which was not unduly dominated by one trait. The mean total asymmetry score (MTA) per individual was therefore calculated by summing asymmetries across all traits and dividing by the number of traits:

$$\sum_{i=1}^4 (Li - Ri)/4$$

where Li = the left side measure of character i and Ri the right side measure of character i .

Table I. Repeatabilities or intra-class correlation coefficient (r_1) and F -values for between-individuals differences in asymmetries for day -1 and day 0 (ovulation). All values were calculated using repeated measures ANOVA

	Day -1			0 (ovulation)		
	r_1	F	P	r_1	F	P
Ears	0.69	5.53	0.001	0.74	6.79	0.0001
Third digit	0.65	4.65	0.0001	0.65	4.77	0.0001
Fourth digit	0.68	5.23	0.0001	0.83	10.86	0.0001
Fifth digit	0.86	13.56	0.0001	0.71	5.95	0.0001
Overall asymmetry	0.90	18.28	0.0001	0.90	19.85	0.0001

r_1 = intra-class correlation coefficient

Table II. Test for departures from zero and normality (Shapiro-Wilk test) of mean signed asymmetries

Trait	t -Test mean	SE	t	P	Shapiro-Wilk test r
Ears	-0.122	0.246	0.5	0.62	0.985
3rd digit	-0.039	0.178	0.2	0.83	0.981
4th digit	0.163	0.203	0.8	0.43	0.996
5th digit	0.109	0.281	0.39	0.70	0.980

Critical r for correlation between signed asymmetries and N scores for $n = 27$ is >0.958 ; therefore the traits in Table II show no significant departure from normality.

Repeatabilities of trait asymmetries were calculated for measurements taken on day 0 (day of ovulation) and day -1, thus controlling for possible changes of asymmetries across the cycle. Repeatabilities (intra-class correlation coefficients) ranged from 0.65 for third digit to 0.9 for MTA. Results of repeated measures ANOVA tests on asymmetries measured twice on day -1 and day 0 confirmed significantly greater variance between individual subjects than between the repeated measures of the same subjects for all traits and MTA (Table I). The means of the signed asymmetries (that is, the result of the calculation $L-R$ which produces + and - asymmetries) on day of ovulation were tested for departures from zero (one sample t -test) and for normality (Shapiro-Wilk test for normal distribution). There were no significant deviations from true fluctuating asymmetry (Van Valen, 1962) (Table II).

Ovulation was taken as the first day the dominant follicle was observed as collapsed [Figs 2 and 3 for changes in all traits and mean total asymmetry (MTA) respectively]. Repeated measures ANOVA showed significant within-subjects changes between days -2, day -1, and day 0 for all traits and particularly for MTA (Table III). The latter observation is not surprising, as summing asymmetries reduces random measurement error (Soule, 1982). Symmetry summed over a number of traits therefore more accurately expresses an individual's genotype than symmetry of single traits (Manning and Ockenden, 1994; Manning, 1995). MTA also demonstrated a 29% reduction on day of ovulation (day 0) compared to day -1 (day 0, mean = 3.764 mm, SE = 0.305; day -1, mean = 5.312 mm, SE = 0.394, Mann-Whitney U -test, z -corrected for ties = -2.985, $P = 0.0028$).

The traits on the side of ovulation showed a total change

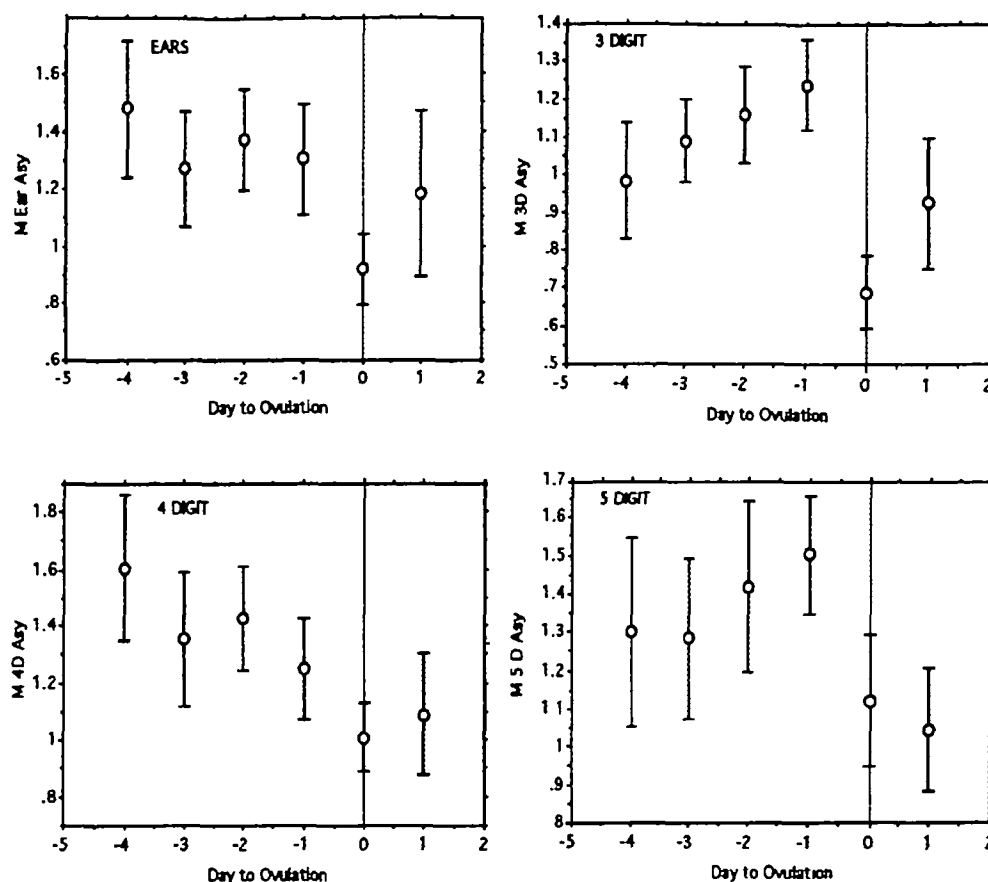


Figure 2. Changes in asymmetry of individual traits across mid-cycle.

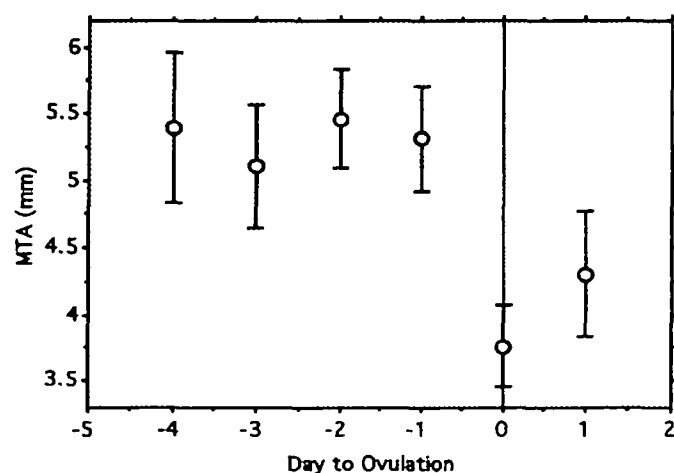


Figure 3. Changes in mean total asymmetry across mid-cycle

Table III. Repeated measures ANOVA for days -2, -1 and 0 (ovulation) for all traits and MTA Within subjects difference

Trait	F	P
Ears	6.156	0.0044
3rd digit	9.429	0.0004
4th digit	3.428	0.0414
5th digit	3.524	0.038
MTA	15.521	0.0001

of mean = -0.07 mm, and on the opposite side mean = -0.17 mm (Mann-Whitney U -test $z = 1.13$, $P = 0.259$). The general trend was for the smaller trait to increase in size, and for the larger to decrease, but to a lesser degree (larger side mean = -0.597 mm, smaller side mean = $+0.36$ mm, Mann-Whitney U -test $z = 4.12$, $P = 0.0001$).

Discussion

In the past asymmetry in humans has been interpreted as indicating developmental instability. Evidence for this includes increased asymmetry in pre-term infants (Livshits *et al.*, 1988), mentally retarded individuals (Malina and Buschang, 1984) and in facial cleft defect and Down's syndrome (Garn *et al.*, 1970). Cyclical changes in symmetry do not invalidate such work. Such changes will merely tend to obscure the relationship between 'permanent' asymmetries and deleterious conditions. These findings do, however, raise practical and theoretical issues.

The practical aspects of this work are addressed first. Changes in soft tissue symmetry may constitute a reliable indicator of ovulation in women. These changes are probably hormonally dependent, and as such could be useful in fertility studies. Four traits were measured, one on the head and three on the hands, which are composed partly of soft tissue. All showed changes in symmetry across mid-cycle. With reference to recent work by Kunz *et al.* (1996), the relationship of the

degree of asymmetry to side of ovulation was investigated, but was not significant. The general trend was for the smaller trait to increase in size, and for the larger trait to decrease, but to a lesser degree.

There is also evidence that breasts show changes in symmetry across the cycle (Manning *et al.*, 1996); therefore it is possible that all paired traits with a soft tissue component will show such changes. Further work is being undertaken in order to establish the nature of the relationship between these changes in symmetry and hormonal levels across the menstrual cycle. We are also currently investigating (i) what is actually changing in the fingers, (ii) which traits are particularly sensitive to changes at ovulation and are easily self-measured, and (iii) whether symmetry in post-menopausal women is influenced by oestrogen replacement.

If males are able to perceive these temporal changes in symmetry, these findings may have evolutionary implications. We have no data which bears on this question so that what follows should be regarded as speculation. Humans and some animal species prefer symmetry to asymmetry (Hubbell 1940; Møller 1992). In humans there is accumulating evidence that both males and females are sensitive to small differences in the body and facial symmetry of others. Body symmetry (of wrists, ankles etc.) has been found to predict facial attractiveness in two studies (Gangestad *et al.*, 1994; Thornhill and Gangestad, 1994) and a measure of facial symmetry predicted attractiveness in both men and women (Grammer and Thornhill, 1994). Possibly as a consequence of these perceptions of attractiveness it was found that (a) the number of lifetime sexual partners was positively related to symmetry, and age at first sexual experience was negatively related to symmetry in men (Thornhill and Gangestad, 1994) and (b) women with partners possessing high symmetry reported more copulatory orgasms than were reported by women with asymmetric partners (Thornhill *et al.*, 1996). It is probable that a correlate of body asymmetry is perceived rather than the asymmetry itself. However, it seems clear that very small inter-individual differences in symmetry may be subconsciously perceived by both men and women and these sexual preferences may be adaptive because symmetry in humans is heritable (Livshits and Kobylanski, 1989). It is therefore suggested that decreases in asymmetry of the order of 30% on the day of ovulation may be seen by males as a sudden increase in attractiveness. Long term cohabitation would facilitate the monitoring of daily changes in symmetry. This is because the total variance in symmetry among women will consist of inter-individual variance and within-individual variance. In this population sense ovulation is cryptic in relation to symmetry. Long-term cohabitation would facilitate the monitoring of daily within-individual changes in symmetry and the relationship between symmetry and ovulation in women could act as an ovulation indicator, but only to a regular male partner. In the context of the evolution of human sexual behaviour such a system could have evolved to encourage males into daily attendance upon females and would also increase their probability of fertilization and their certainty of paternity. An increase in the latter would further promote pair-bonding.

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