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MALE FERTILITY*

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This presentation includes a description of an improved method for judging the degree of male fertility, and the practical application of this testing in the study of the male.

The male should possess an adequate number of normal spermatozoa. This statement immediately raises two questions: What are the characteristics of normal spermatozoa?; and What is an adequate number of them?

It may not be possible to list all of the characteristics of normal spermatozoa, but it is reasonable to believe that one of them is normal motility. If the spermatozoon cannot move it is obvious that it cannot reach the ovum. The movement should be progressive and with a certain speed. Until standards of normality of spermatozoa, other than that of movement, are established, motility of the kind just described might be considered the chief indication of normality. [The film "Human Spermatozoa—Morphology and Motility" was shown at this point.]

The number of active spermatozoa in an ejaculate which are required in order to make fertilization possible is unknown. However, while it is agreed that a single spermatozoon only is actually required for fertilization, yet we realize that the greater the number of active spermatozoa available in an emission the more likely the possibility that a single one may reach the site of fertilization. Theoretically, it was found that 70 million active spermatozoa (Farris, 1950b, p. 173) deposited in the vagina would be required for one spermatozoon to reach the ovum in the upper third of the oviduct. The following observations may throw some light upon the requirements for male fertility.

In my opinion, no previously described method supplies a satisfactory measure of male fertility. Since fertility is dependent on active spermatozoa, it is felt that such criteria as the number of fixed spermatozoa per cubic centimetre, the volume of the specimen, the morphology, and an estimate of the percentage of motility should be supplemented by a count of the

number of active spermatozoa in the total ejaculate. Hotchkiss (1944) stated: "A new and simple method for enumerating and grading motility is needed to meet the requirements encompassing all factors concerned with motility of sperm." This includes the actual percentage of active cells, type of motility, and duration of activity.

Technique

With these needs in mind, I have developed what I believe is an improved method for estimating the index of fertility of the male. The technique is as follows:

After five days of freedom from emission, the individual collects his total ejaculate in a sterile wide-mouthed bottle, either by masturbation or by coitus interruptus. The specimen is never collected in a rubber sheath, and must not be heated. It is examined one hour later in order to permit a certain degree of liquefaction to take place. The examination consists primarily in computing the number of active spermatozoa in the entire ejaculate.

The counting is carried out in the following manner. A few drops of the well-mixed semen are diluted 1 in 20 with Locke's solution in a white-blood-cell counting pipette. The moving cells are counted upon a red-blood-cell counting-chamber, using the low-power objective of the microscope. The number of active spermatozoa per cubic centimetre of the specimen is computed. With the volume of the ejaculate known, the total number of active spermatozoa in the entire ejaculate is determined. The resulting figure, referred to as the absolute motility, and expressed in millions of active cells, is employed as the measure (index) of the individual's fertility. [The film "Human Semen Analysis: a Technic for Counting Motile Spermatozoa" was shown at this point.]

A basis for classification of male fertility (Farris, 1949b) was determined by the comparison of semen analyses of three groups of men: (a) those whose wives conceived without difficulty, and who had had two or more children; (b) men whose wives conceived with difficulty; and (c) individuals whose wives failed to conceive. With the absolute motility figures from each of these three groups of men as the unit of measurement, it is possible to classify male fertility in one of the four following categories: (a) high fertility (185 million or more active spermatozoa), (b) relative fertility (80 to 185 million active spermatozoa), (c) subfertility (below 80 million active spermatozoa), and (d) sterility (with no active spermatozoa).

With the co-operation of medical students and physicians, three sets of observations were made to determine

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the effects on their active spermatozoa counts of (1) frequency of emission, (2) ageing of spermatozoa *in vitro* and *in vivo*, and (3) physical fatigue. [The film "Human Semen Analysis: Motile Spermatozoa as an Index of Fertility in Men" was shown at this point.]

FIG. 1.—Active spermatozoa in relation to fertility (three consecutive days). Showing effects of daily emissions on three groups of men with different degrees of fertility. Note that (1) the highly fertile group remains fertile (80 million or more active spermatozoa) for three consecutive days; and (2) the relatively fertile group is fertile only on the first day.

FIG. 2.—Active spermatozoa in relation to fertility. Showing effects of emissions on alternate or at two-day intervals on two groups of men with different degrees of fertility. Note that (1) the highly fertile group remains fertile for three days; and (2) the relatively fertile group drops to a lower level of fertility.

FIG. 3.—Active spermatozoa in relation to fertility. Showing effects of emissions in three groups of men with different degrees of fertility. Second sample of semen obtained six hours later. Note that only the highly fertile group recovered to a fertile level.

Effect of Frequency of Emission

Spermatozoa Counts on Three Consecutive Days: Groups of Individuals.—Fig. 1 shows the differences in the average counts of active spermatozoa secured on three consecutive days.

The highly fertile group is fertile (above 80 million active cells) for three consecutive days. The relatively fertile group is fertile only on the first emission after five days' abstinence. The second and third emissions place these individuals in the subfertile class (fewer than 80 million active cells). This observation offers an important distinction in the differential classification between highly fertile and relatively fertile individuals. Those persons who possess 185 million or more active spermatozoa after five days' abstinence continue to have active cell counts above the 80 million level of fertility on the next day, while those with fewer than 185 million active spermatozoa on the first day drop below the 80 million level into the subfertile class on the next and subsequent days. The subfertile males exhibit an unsatisfactory count during the entire three days of testing.

Spermatozoa Counts at Two-day Intervals: Groups of Individuals.—Fig. 2 shows the differences in the active counts of two groups of males at two-day intervals. The two groups are similar in that both show a definite drop in the active cell count. The semen specimens of the relatively fertile group dropped to practically a subfertile level.

Spermatozoa Counts at Three and Four-day Intervals: Groups of Individuals.—Our observations show that the highly fertile group dropped to the relatively fertile class in three-day intervals. The four-day interval count often reached the level of the first (control) count. The relatively fertile group remained in the relatively fertile class at three-day intervals, but often failed to reach the level of the first emission after a four-day interval.

Spermatozoa Counts at Six-hour Intervals: Groups of Individuals.—Fig. 3 shows the absolute motility count of specimens of semen secured at the end of six hours. The highly fertile group became relatively fertile. The relatively fertile group, with

FIG. 4.—Showing effects, in a bottled specimen, of ageing on total number of active spermatozoa (45 subjects). Counts were made at intervals during a 24-hour period. The highly fertile group with more than 39% active cells maintained a higher degree of fertility for a longer period of time than did the group with less than 33% of active cells at start of observations.

136 million motile spermatozoa, became subfertile and showed a count of 43 million active cells in six hours. The subfertile group remained subfertile, with a count of 28 million moving spermatozoa. This finding is of value, particularly for the borderline individual. Coitus practised twice within six to eight hours would make available a greater number of active spermatozoa at the optimum time for fertilization than if intercourse were practised only once.

From our observations we conclude: (1) a minimum of five days' abstinence is required for most men to reach their maximum level of fertility; (2) emissions either daily or on alternate days reduce the relatively fertile male to practically a subfertile level; and (3) coitus twice within six to eight hours may prove a useful method for aiding the wife of the relatively fertile or subfertile husband to conceive.

Effect of Ageing on Spermatozoa

Another set of observations was carried out in order to determine the effect of ageing upon the motility of spermatozoa when maintained (1) *in vitro* in the specimen bottle for 24 hours, and (2) in the female reproductive tract for 24 or more hours.

Ageing In Vitro

Fig. 4 shows a comparison of findings from specimens collected *in vitro*, secured from two groups of men classified as highly fertile, two groups classified as relatively fertile, and one group classified as subfertile. The specimens were examined at intervals over a period of 24 hours. The spermatozoa from the highly fertile first group, with the higher percentage of motility, maintained their motility at the fertile level for approximately 19 hours. The spermatozoa of the relatively fertile group maintained their motility at the fertile level for only nine hours. The second highly fertile group, with less than 33% active cells at the start, dropped in cell motility below the fertile level within a period of six

hours. Although not shown in the graph, we observed, in those specimens beginning with a lower motility, that the progressive action of the spermatozoa changed to an oscillating type of action within a very few hours, and the cells became inactive in about 12 hours.

These observations suggest: (1) Specimens classified as highly fertile may remain in this classification *in vitro* for about 19 hours, while specimens in the relatively fertile group remain in that classification for only nine hours; (2) for proper classification, semen specimens should be examined preferably within the first and second hours after the emission, because of the rapid drop in motility.

Ageing In Vivo

The duration of the life of spermatozoa was studied in the female reproductive tract. With the aid of several co-operating Philadelphia gynaecologists, hysterectomies were performed on patients after insemination with highly fertile semen. Normally progressive spermatozoa were recovered from the cervix, uterus, and oviducts up to 48 hours after insemination. In view of the normal progressive motility of spermatozoa at the end of this time, it is believed that they could have lived much longer. I believe, however, that the fertilizing power of the semen is lost in about 12 to 24 hours, because when inseminations were carried out 24 hours before or after the predicted time of ovulation no conceptions resulted.

Effect of Physical Fatigue on Spermatozoa

In view of the fact that physical fatigue is believed by many to affect spermatozoa, observations were undertaken to test its effect on the semen count. Semen specimens were secured from eight college football players, six of whom were fatigued by a competitive game. The degree of fatigue was rated by the differential blood count, on the basis of previous work (Farris, 1943). Fatigue is indicated when the lymphocyte count averages between 10 and 20%, rather than the normal of 25 to 35%. Six players who averaged 53 minutes' playing time

showed practically the same semen counts as their controls, studied three weeks later. Two players who averaged 15 minutes' playing time also showed practically no changes in their semen counts.

It is concluded from these observations that extreme physical fatigue does not affect the spermatozoa counts.

Variations in Semen Analyses

Observations were made to determine what variations occur in the semen of an individual over a period of time. It was important to determine the reliability of a single semen analysis when compared with repeated examinations at other times.

Our observations (Farris, 1950b, p. 135) indicate that the counts of the highly fertile male remain constant on re-examinations, and keep him in the highly fertile class. For this reason, repeat counts on the highly fertile men probably are unnecessary. On the other hand, the counts of relatively fertile and subfertile individuals are more variable. Consequently re-examinations of these persons are necessary before final judgment is passed regarding their fertility.

Temporary Subfertility or Sterility.—In addition to normal variations in semen analyses, we have observed that occasionally individuals exhibit temporary subfertility or even sterility, resulting from illnesses, type of work, or other conditions. For example, one patient had absolute motility counts of 64 million and 35 million spermatozoa after a severe throat infection which required admission to hospital for about a week. A year and a quarter later his semen analysis revealed 188 million active cells, and soon afterwards his wife conceived.

In another instance a patient had 14 million, and on re-examination 8 million, active spermatozoa in the total ejaculate. Several months later this individual became azoospermic. It was learned that he was taking steam baths regularly once a week. After six weeks without taking steam baths he revealed a 20 million absolute motility count.

Criteria of Normal Semen

The standards given in Table I were derived from the data from the foregoing observations and from the findings gathered from other semen analyses on proved fertile males. The median values listed in Table I were

TABLE I.—Standards

Minimum Standards for Fertility	Median (Based on 200 Pregnancies)	Range
Volume: 2.5 ml. up	4 ml.	1.1–11 ml.
Speed: 0.7–1.2 sec.*	1 sec.	0.5–3.6 sec.
Morphology: 80% or more oval forms	87%	48–99%
Motility: 38% active spermatozoa	44%	15–68%
Active per ml.: 20 million up	51 million	10–148 million
Index of fertility is based on the number of active spermatozoa in the entire ejaculate in millions. (Absolute motility.)		
Highly fertile .. 185 up	209 million	45–729 million
Relatively fertile 80–185		
Subfertile .. 1–80		
Sterile .. 0		

* Speed is based on timing of 25 progressive spermatozoa.

If the first specimen is relatively fertile, subfertile, or questionable, re-examination should be made in about a month. Eighty million moving cells in the entire ejaculate are required for conception by coitus. (Semen analysis is preceded by five days' abstinence.)

An occasional pregnancy (in about 3% of the cases) has occurred when the semen analysis failed to measure up to the above minimum standards.

secured from a study of 200 samples of spermatozoa. These specimens were secured from husbands whose wives conceived while the couples were being studied for sterility.

The minimum standards for fertility are based upon semen specimens secured from husbands whose wives experienced difficulty in conceiving because of less satisfactory specimens. Pregnancy occurred in only about 3% of the cases in which the semen analyses failed to measure up to the minimum standards. Yet, in advising males regarding their fertility status, we tell them that so long as they have active spermatozoa there is a chance of fertilization, no matter what the count may be. We emphasize, however, that the higher the total number of moving cells in the ejaculate the greater the possibility of conception.

The wives of 10% of the subfertile men conceived after being aided by precise ovulation timing and proper coital advice.

Fertility in Relation to Age

Table II shows that in early reproductive life fertility can be classified on the basis of absolute motility, and that this degree of absolute motility probably remains more or less constant throughout the greater part of the

TABLE II.—Percentage Index of Fertility According to Age Groups

Age	Classification in Percentages			
	Highly Fertile	Relatively Fertile	Subfertile	Azoospermia
14–20	41	37	15	7
21–25	43	35	16	6
26–30	38	30	26	6
31–35	39	29	23	9
36–40	35	32	25	8
41–45	48	26	26	0
46+	25	25	44	6
Whole group (643 individuals)	39	31	23	7
	70		30	

reproductive period. Data beyond age 45, based upon 16 cases, are insufficient to permit accurate classification. The fertility level does not change with age, as shown by statistical analysis of the semen specimens of the group. The summary of all ages indicates that 70% of the men were highly or relatively fertile; and 30% were subfertile or sterile, since 7% had no sperm cells.

Frequency of Intercourse

The information presented above can be applied practically when the facts regarding the normal frequency of intercourse in the human male are known. Table III lists the frequency of coitus of married white males with fertility problems. The average rate in this

TABLE III.—Frequency of Intercourse of Married White Males with Fertility Problems

Age	Average Coital Rate Per Week	No. of Individuals
21–25	3.0	37
26–30	2.8	147
31–35	2.8	164
36–40	2.4	94
41–45	2.1	28
46–50	2.2	8
Total No. of Individuals		478

84%

group for ages 21 to 35 is three times a week, and from 36 to 50 a little oftener than twice a week.

Since relatively fertile and subfertile individuals become infertile unless they have a rest period of five days, for conception purposes it is particularly necessary that these individuals abstain from intercourse for five days before the anticipated day of ovulation.

Clinical Observations

The routine procedure in studying, counselling, and treating the childless couple has been as follows: (1) The number of active sperm cells in the total ejaculate of the husband is determined; (2) the patency of the wife's Fallopian tubes is studied by hystero-graphy; (3) the wife is timed for the date of her ovulation. Knowledge of these three conditions has made it possible in many cases to predict with a considerable degree of accuracy whether or not conception will occur.

One Hundred Sterile Couples: Classification of Husbands.—Consideration of how 100 so-called sterile couples were aided through our laboratory may be of interest. Of 100 husbands 40% were classified as highly fertile, 30% as relatively fertile—a total of 70% considered fertile—10% were classified as subfertile, and 17% as sterile, the latter possessing no spermatozoa. In this group of 100 couples there were three instances in which there existed an Rh blood incompatibility. Of the 100 wives, 23 conceived after donor insemination. It is interesting to note that the classification of the fertility of these 100 husbands agrees closely with that of another larger group of 643 men, of whom 70% were considered fertile and 30% subfertile. We might add that in a third series of 1,000 counts on both married and unmarried men the findings were similar.

One Hundred Sterile Couples: Classification of Wives.—Factors which contributed to sterility in the 100 wives are as follows: Tubal obstructions, 13%—it is probable that lipiodol may have aided in these cases—7% of the women had endocrine disturbances, 2% had bicornate uterus, and in 1% a congenital anomaly was evident in which only one ovary was present. Every wife conceived after being aided by determining the time of ovulation by my method (Farris, 1946b). The menstrual cycles averaged 24 to 37 days in length. Conceptions occurred during cycle days 9 to 23, inclusive. The great majority of conceptions occurred on cycle days 11, 12, and 13. The individuals who conceived on cycle day 11 demonstrated average menstrual cycle lengths of from 24 to 31 days.

Treatments: Effect on Subfertile Men

Gonadogens, thyroid, various pituitary products, and four types of vitamin E were administered to a series of subfertile men with the object of improving their sperm counts. No improvement was noted in any of the cases.

Another series of subfertile men received pituitary irradiation with the same objective in mind. These individuals fell into two groups. The first group exhibited 50 million or more moving cells—80% of these individuals responded to the treatment, but this response was only temporary. The second group had fewer than 50 million moving cells. This group responded, but not to the same extent as the preceding group.

Aids to Male Fertility

The following recommendations are offered. (1) Classify the males regarding their fertility on the basis of the total number of active spermatozoa in the ejaculate. (2) Advise the couple to abstain from intercourse for the five days prior to the day of ovulation. This brings the active sperm count to its highest level. (3) When the ovulation date can be determined, concentrate coitus on the precise day. Otherwise, advise coitus during the fertile period—namely, cycle days 11, 12, and 13, depending upon the length of the average menstrual cycle. (4) For the subfertile male, concentrate coitus twice within eight hours on the day of ovulation. For the relatively fertile male, concentrate coitus twice within eight hours or in the late evening and the following early morning, about the time of ovulation. For the highly fertile male, advise coitus for three consecutive days during the selected period. The female should be studied for factors which may contribute to sterility.

It is hoped that the application of the observations which form the basis of this paper may be useful in helping to solve some of the problems which arise in the diagnosis and treatment of sterility in the male.

BIBLIOGRAPHY

- Corner, G. W., Farris, E. J., and Corner, G. W., jun. (1950). *Amer. J. Obstet. Gynec.*, **59**, 514.
 Farris, E. J. (1943). *Amer. J. Anat.*, **72**, 223.
 — (1946a). *Anat. Rec.*, **95**, 337.
 — (1946b). *Amer. J. Obstet. Gynec.*, **52**, 14.
 — (1947). A Technic for Counting Motile Spermatozoa. Motion picture film, 16 mm., monochrome, silent, phase microscopy.
 — (1948a). *Amer. J. Obstet. Gynec.*, **56**, 347.
 — (1948b). *J. Amer. med. Ass.*, **138**, 560.
 — (1949a). *Ann. N.Y. Acad. Sci.*, **52**, 409.
 — (1949b). *J. Urol.*, **61**, 1099.
 — (1950a). *Ibid.*, **63**, 748.
 — (1950b). *Human Fertility and Problems of the Male*. The Author's Press, Palisades Park, New Jersey.
 — (1950c). *Human Semen Analysis: a Technic for Counting Motile Spermatozoa*. Revision. Motion picture film, 16 mm., monochrome, silent, phase microscopy.
 — (1950d). *Human Semen Analysis: Motile Spermatozoa as an Index of Fertility in Men*. Motion picture film, 16 mm., monochrome, silent.
 — (1950e). *Human Spermatozoa: Morphology and Motility (Spermatozoa of Vertebrates, Reel III)*. Studies of living sperm by phase microscopy. Motion picture film, 16 mm., monochrome, silent.
 — and Murphy, D. P. (1948). *Rev. méd. Cordoba*, **36**, 199.
 Hotchkiss, R. S. (1944). *Fertility in Men*, p. 110. Lippincott, Philadelphia.
 Murphy, D. P., and Farris, E. J. (1947). *Amer. J. Obstet. Gynec.*, **54**, 467.
 — (1948). *J. Amer. med. Ass.*, **138**, 13.

The fifth annual conference of Army Pathologists was held on October 4 and 5 at the Royal Army Medical College, Millbank. On the first morning demonstrations were given of Price's precipitation reaction, a technique for Rh blood grouping using small quantities of serum and devised by Major I. D. P. Wootton, and a number of histopathological sections of rare and interesting tumours. An administrative meeting was held in the afternoon. On the second day, lectures were given by guest lecturers. Dr. C. H. Andrewes, F.R.S., spoke on the epidemiology of influenza, and was followed by Dr. A. Isaacs on the laboratory diagnosis of this disease. Professor R. J. V. Pulvertaft described phase-contrast microscopy, and illustrated his talk with a film made by intermittent photography of bacterial slide cultures using this technique. Professor N. F. MacLagan ended the morning session with a lecture on liver function tests. Sir Alexander Fleming, F.R.S., chose as his subject bacteria versus antibiotics, and Dr. H. J. Parish discussed some aspects of immunity following injections of toxoids.