Morphometric Analysis of Spermatozoa in the Assessment of Human Male Fertility

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A videomicrographic system was developed for measurement of morphometric parameters of human spermatozoa. Contours of the images of spermatozoa on a video monitor are digitized by manually tracing them with the cursor of an electromagnetic digitizer integrated to a microcomputer. The accuracy and precision of the methodology were evaluated. A comparison of human sperm heads in shallow wet preparations and in dried, stained preparations indicated that the latter were smaller in length, width, projected area, and circumference, but that the ratio length/width was not different. An analysis was made of 457 ejaculates from 16 fertile donors. The variation between ejaculates within donors was similar in magnitude to the variation between donors. A study was performed comparing seminal sperm morphometry in single specimens from 30 fertile and 30 infertile men. The sperm head length/width ratio was the parameter that differed the most between these two groups. Moreover, it was the per-ejaculate variability of this parameter, rather than the central tendency, that maximized the difference.

Key words: human spermatozoa, morphometry, fertility, videomicrography.

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Prediction of male fertility potential on the basis of semen quality remains a desirable but elusive goal. It has been recognized for many years that the number of spermatozoa, as well as their movements and morphologic characteristics, are related to the fertility of a semen specimen (MacLeod and Gold, 1951; Hartmann, 1965; Freund, 1968; Eliasson, 1975). If we are to develop a deeper understanding of these relationships and their predictive value, semen characteristics must be measured objectively and under standardized conditions. In addition, the fertility of populations of semen donors must be established carefully. Until recently, the number of spermatozoa has been virtually the only characteristic of human semen to be measured objectively and quantitatively. There has been considerable interest in the objective measurement of the movement of ejaculated spermatozoa (Janick and MacLeod, 1970; Katz and Dott, 1975; Makler, 1978; Overstreet et al, 1979; Amann and Hammerstedt, 1980; Katz and Overstreet, 1981). These techniques are gaining increasing application in both basic and clinical studies (Hoskins et al, 1978; Katz et al, 1981; Aitken et al, 1982; Amann et al, 1982).

In contrast, the assessment and interpretation of the morphology of ejaculated spermatozoa have not benefited from comparable developments or activity. The clinical assessment of human semen usually includes a determination of the percentage of morphologically "normal" spermatozoa. Certain types of abnormality, such as headless and multiple-headed or tailed spermatozoa, can be quantitated objectively. As early as 1966, however, a comparative study in 47 laboratories of the type-classification system for human sperm morphologic assessment showed that the method was "personality oriented," as well as "subjective, qualitative, nonrepeatable, and difficult to teach to students and technicians" (Freund, 1966). Little progress has been made since then. The difficulty in classifying human sperm morphology is compounded by the fundamental biologic fact that

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ejaculated spermatozoa do not conform to discrete categories of size and shape. Unlike the hematopoetic cells, for example, spermatozoa appear in an almost infinite variety of forms. Metric standards have been cited for the dimensions of a "normal" human sperm head (Eliasson, 1975), and we have applied them in research studies (Overstreet et al, 1981; Katz et al, 1982). However, neither a biologic nor clinical basis for these "normal values" has yet been provided. Consequently, there are no objective morphologic criteria for defining normal spermatozoa in human semen at the present time. Such criteria can be established only on the basis of extensive studies that assess the morphometric characteristics of spermatozoa. There have been a few earlier investigations of the dimensions of human sperm heads (van Duijn, 1957, 1964; van Duijn et al, 1972; Schmassmann et al, 1979). These investigations did not establish the fertility of the donors. Their data, however, are instructive because of the implication that morphometric diversity in a semen specimen may be a useful measure of morphologic integrity. It should be appreciated that human sperm head morphology may not relate to DNA content, for the latter can vary while the former does not (Leuchtenberger et al, 1955). Indeed, heterogeneity of DNA content may be useful in discriminating between the semen of fertile and infertile men. The early studies of sperm diversity in semen are supported by the clinical observation that spermatozoa in fertile human semen are fairly uniform in size and shape. In this respect, the "best" human semen resembles that of other mammals. In contrast, abnormal humen semen contains a diversity of head sizes and shapes, and the extent of this diversity appears to correlate with the overall degree of abnormality.

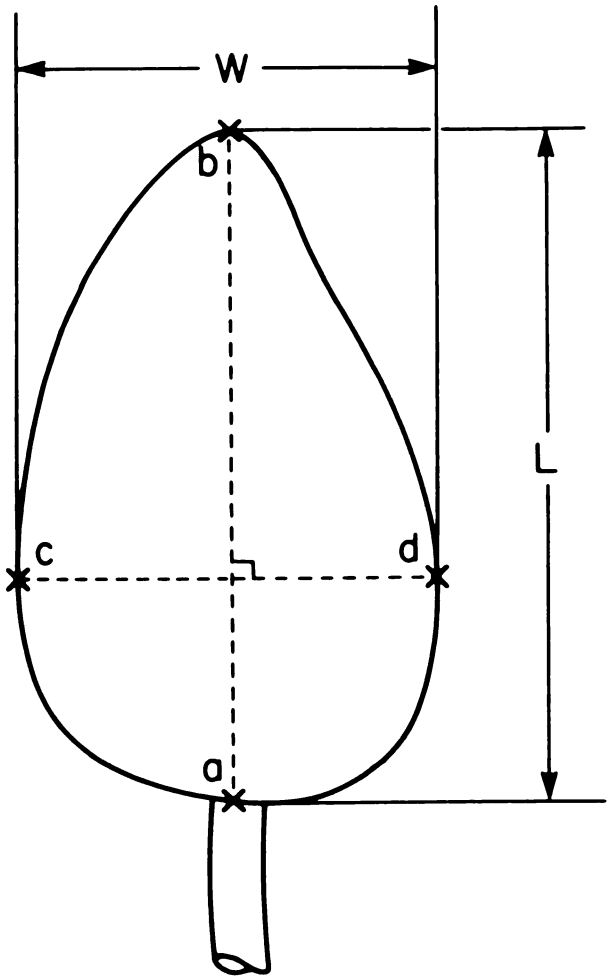

Fig. 1. Definition of the length (L) and width (W) of a sperm head. For details, see text.

In the present study, we have analyzed the accuracy and precision of a videomicrographic system for assessing sperm size and shape. We have considered different methods of specimen preparation. We began the biomedical application of this system by considering repeated ejaculates from a group of fertile donors, and by comparing single specimens from well-defined groups of fertile and infertile men. In so doing, we have studied the use of statistical measures of the within-specimen variability of sperm head dimensions in discriminating between the fertile and infertile men.

Materials and Methods

General Methods for Morphometric Measurement of Spermatozoa

Morphometric parameters of human sperm heads were measured from images displayed on a videomonitor. Spermatozoa in stained seminal smears (see below) were observed using an Olympus BH2S microscope (San Jose, CA) with a 100 × oil immersion plan apochromatic bright-field lens (N.A. 1.3); the condenser (N.A. 1.4) was used dry. Observation of spermatozoa in wet mounts was performed using a 100 × oil immersion plan apochromatic phase contrast lens (N.A. 1.3); the phase contrast condenser (N.A. 1.4) was used dry. An RCA 1000 B & W video camera (New York, NY) sighted through a 3.3 × photo-ocular lens and transmitted the image to a Conrac Model CQF, 17-inch television monitor (Campbell, CA). The final magnification on the television screen was ×9071. The screen was calibrated for linearity, and measurements were restricted to a central region within which the relative error was ≤ 2% in both the vertical and horizontal directions. In preliminary experiments, measurements of sperm head length and width were made by application of a set of calipers to the screen. Subsequently, measurements were performed by direct application of the cursor

of a Numonics Model 1224 digitizer (Lansdale, PA) to the screen. The absolute accuracy of such measurements in this system is ± 0.05 μm. Digitizer output was transmitted automatically to an Apple II+ microcomputer for storage and initial analysis.

A set of four morphometric parameters was obtained. The definitions of these parameters are illustrated in Fig. 1. Only sperm heads with broad sides parallel to the plane of focus were considered. Since the heads of human spermatozoa may not be bilaterally symmetric, head length (L) and width (W) must be carefully and objectively defined. We measured length as the distance between the midpoint of the insertion of the flagellar midpiece with the head (Fig. 1, point a) and the point farthest (b) from it. Head width was then defined as the length of the longest line perpendicular to line ab and intersecting the sides of the sperm head (Fig. 1). In some experiments, sperm head circumference (C) was directly obtained with the digitizer by tracing the border of the head, and in so doing the projected area (A) was computed automatically. In characterizing the shape of the head, the aspect ratio (length/width) also was determined.

Fixed, stained preparations of spermatozoa were made using the method of Papanicolaou (1942). This is a multistep procedure in which the sperm nucleus is stained with hematoxylin. Spermatozoa were prepared for observation in wet mounts by compressing 1 μl of semen between a microscope slide and coverglass (22 mm × 22 mm). The great majority of spermatozoa in the wet mounts were immobilized and aligned with the broad sides of their heads in the plane of focus. Only such spermatozoa were measured.

Statistical characterization of the data for each semen specimen was designed to express the variability in the measurements among the spermatozoa as well as the central tendency. Thus, the sample standard deviations and mean values (and their logarithms) were used as summary statistics. All samples studied were fresh.

Evaluation of the Methodology

Precision of Measurements of Individual Spermatozoa. The head length and width of fifty spermatozoa on a stained slide from a fertile donor were measured consecutively three times by an experienced analyzer. Between repeated measurements, the analyzer unfocused the microscope and removed each spermatozoon from the field of view, without knowledge of the prior measurement(s). Preliminary analysis showed no tendency for the second and third measurements to be more alike than the first and second. Therefore, the three successive measurements were treated as independent. A variance components analysis (Snedecor and Cochran, 1973) was used to partition the total variation into a technical component (repeated measurements per spermatozoon) and a biologic component (variation among different spermatozoa in the sample).

Sampling Variability Inherent in the Measurement of a Finite Number of Spermatozoa per Specimen. The sampling variability in per-ejaculate mean values and standard deviations, based on n = 50 spermatozoa, was simulated as follows. One stained slide was selected from each of 20 fertile donors, and the head length and width of 100 spermatozoa per slide were measured. Two hundred samples (n = 50) were drawn with replacement from this "population" of 100 spermatozoa. The mean and standard deviation for each new sample were recorded. It has been proven mathematically that this procedure simulates the results that would be obtained if independent repeated samples were selected from the original slide (Efron, 1982).

Comparison of Sperm Morphometry in Wet Mounts and Dried-Stained Preparations. In these experiments, single semen specimens from eight fertile men were studied. Spermatozoa in wet mounts were visualized with 100 × magnification oil immersion, plan-apochromatic phase-contrast optics (see above), and 100 spermatozoa per specimen were analyzed. Sperm head length, width, projected area, and circumference were measured, and the aspect ratio was also determined. A dried-stained preparation also was made for each specimen, and 100 spermatozoa were similarly analyzed, using 100 × oil immersion plan-apochromatic brightfield optics. The standard deviations and means were analyzed using paired *t*-tests after transformation to the log scale.

Biomedical Application of the Methodology

Variation of Sperm Morphometry in Repeated Ejaculates of Individual Fertile Men. Stained slides from a total of 457 fresh ejaculates from 16 fertile donors in our therapeutic artificial insemination program were analyzed for head length (L) and width (W). All were specimens used in the program. The number of specimens per donor ranged from nine to 80. We studied the means and log-standard deviations per ejaculate of length, width, length/width, and length × width (the logarithm was necessary to equalize within-donor variation). In pilot experiments, we found that length × width correlated strongly with head area ($r = 0.951$, $n = 200$, $P < 10^{-6}$). This statistical technique enabled us to partition the total variance into components for repeated specimens within men and for differences among men. For each specimen, we also estimated a percentage of "normal" morphologic forms, using a metric overlay to the video images of the sperm heads (Overstreet et al, 1981; Katz et al, 1982). The resulting data were transformed to logits in order to equalize within-donor standard deviations. Coefficients of variation were calculated on the original scale because, on the logit scale, the absolute value of a mean near 50% is artificially small. The variance components procedure of the Statistical Analysis System (SAS Institute, Inc, 1982) was employed in these computations; the Type I (Analysis of Variance) option was chosen.

Comparison of the Dimension of Sperm Heads in the Semen of Fertile and Infertile Men. Single semen specimens were analyzed from 30 proven fertile donors in our therapeutic artificial insemination program, and from 30 men in marriages of long-standing infertility. These patients were defined as infertile since their wives had conceived after artificial insemination with donor semen. All of the patients had "abnormal" sperm morphology by standard clinical criteria, but there was no preselection of the group on the basis of semen quality. Fifty spermatozoa on each stained preparation were analyzed for length, width, length/width, and length × width. Two-sample

TABLE 1. Precision of Repeated Morphometric Measurements of Individual Sperm Heads, as Described by a Variance Components Analysis*

Statistics	Morphometric Parameter			
	Length (μm)	Width (μm)	Length/Width	Length × Width (μm²)
Mean	4.81	3.32	1.47	15.96
Among-sperm standard deviation (coefficient of variation)	0.430 (8.9)	0.381 (11.5)	0.219 (14.9)	2.327 (14.6)
Measurement standard deviation (coefficient of variation)	0.065 (1.4)	0.055 (1.7)	0.030 (2.0)	0.370 (2.3)

*Fifty spermatozoa were each measured three times by a single analyzer. Coefficients of variation are expressed as percentages.

t-tests were applied to the logarithms of the per-specimen means and standard deviations of each morphometric parameter.

Results

Evaluation of the Methodology

Precision of Measurements of Individual Spermatozoa. Table 1 summarizes the mean values and the among-sperm and measurement standard deviations and coefficients of variation. The coefficients of variation (CV) due to measurement alone ranged from 1.4 to 2.3%. The coefficients of variation resulting from variation among spermatozoa ranged from 8.9 to 14.9%.

Sampling Variation Inherent in the Measurement of a Finite Number of Spermatozoa per Specimen. Table 2 presents the simulated coefficients of variation, averaged over the 20 specimens, for samples of 50 spermatozoa. The coefficients of variation for the ejaculate means ranged from 1.7 to 2.8%. For the ejaculate standard deviations, the range was 11.9 to 14.9%.

Differences in Sperm Morphometry in Wet Mounts and Dried-Stained Preparations. Sperm heads in the stained preparations were consistently smaller than those in wet mounts (Table 3). Stained spermatozoa were, on the average, 14% shorter, 16% narrower, 15% smaller in circumference, 30% smaller in projected area, and 3% greater in aspect ratio than were spermatozoa in wet preparations from the same specimens. The within-specimen variability was also less in the stained preparations (Table 4). As measured by the standard deviation, this variability, when statistically significant, was 39% less for width, 47% less for area, and 25% less for circumference.

TABLE 2. Coefficients of Variation (%) of Morphometric Summary Statistics for Subsamples (n = 50) Drawn from Populations of 100 Spermatozoa*

Summary Statistic	Morphometric Parameter			
	Length (μm)	Width (μm)	Length/ Width	Length × Width (μm²)
Mean	2.0	1.7	2.8	2.6
Standard deviation	12.7	11.9	14.9	12.7

*Values are averages over single slides from 20 semen specimens in each of which 200 random subsamples were drawn.

Biomedical Application of the Methodology

Variation of Sperm Morphometry in Repeated Ejaculates from Individual Fertile Men. Table 4 summarizes the results of the variance components analysis, in which the total variability in sperm morphometric parameters was partitioned into within-donor and among-donor components. When the ejaculate mean was used as the summary statistic, the coefficients of variation ranged from 4.6 to 9.1% overall, and were not appreciably different for the within-donor and among-donor components. When the logarithm of the ejaculate standard deviation was used as the summary statistic, different results were obtained. The coefficients of variation for length, width, and length/width were higher overall and, notably, appeared greater for the within-donor variation than for the among-donor variation. The latter was also true for length × width. The median value of the percentage of normal forms was 56%, and the range was 36% to 69%. The variance components analysis yielded an average within-donor coefficient of variation of 22% and an average among-donor value of 18%.

Differences in the Morphometry of Sperm Heads from Semen of Fertile and Infertile Men. The sample distributions for the morphometric parameters tended to exhibit some positive skewness. The results presented, therefore, will reflect statistical analyses after a logarithmic transformation of the sample means and standard deviations. Results obtained

TABLE 3. Comparison of Morphometric Parameters of Spermatozoa in Wet, Living and Fixed, Stained Preparations*

Summary Statistic	Specimen Preparation	Morphometric Parameter				
		L (μm)	W (μm)	A (μm²)	C (μm²)	L/W
Mean	Wet	5.26 (5.18–5.35)	3.37 (3.26–3.48)	13.91 (12.61–15.23)	13.73 (13.43–14.03)	1.59 (1.50–1.67)
	Stained	4.54† (4.34–4.74)	2.82† (2.71–2.92)	9.79† (8.88–10.71)	11.70† (11.36–12.05)	1.63 (1.54–1.71)
Standard deviation	Wet	0.610 (0.524–0.700)	0.408 (0.346–0.474)	2.687 (2.073–3.311)	1.269 (1.065–1.477)	0.240 (0.196–0.288)
	Stained	0.504 (0.434–0.580)	0.251‡ (0.143–0.363)	1.430§ (1.200–1.670)	0.950§ (0.832–1.072)	0.259 (0.197–0.325)

*Values are expressed as the geometric mean (95% confidence limits). The latter were computed on the log scale and then transformed back to the linear scale for presentation. The symbols are: L = length; W = width; A = projected area; C = circumference. Statistically significant differences are indicated as: † $P < 0.001$; ‡ $P < 0.01$; § $P < 0.05$.

without such a transformation were similar. The spermatozoa of fertile and infertile men were not significantly different in length or length × width (Table 5). There were slight, though statistically significant, differences ($P < 0.05$) in width (5% less for infertile men) and length/width (7% greater for infertile men). Much larger distinctions appeared between the two groups of men when the within-specimen variability was analyzed, that is, there was much more variability in the semen of the infertile men. The sample standard deviation was on the average 11% greater for width ($P < 0.05$) and 24% greater for length/width ($P < 0.01$). There were no significant differences in the standard deviations of length or length × width. The sample coefficient of variation for the infertile men was 14% greater for length ($P < 0.05$), 17% greater for width ($P < 0.001$), and 18% greater for length/width ($P < 0.01$). There was no significant difference in the coefficients of variation for length × width.

Discussion

In evaluating the precision of our methodology, we considered both a purely technological component (Table 1) and a component due to sampling of a finite number of spermatozoa (Table 2). As seen in Table 1, the relative variation (coefficient of variation) due to a measurement itself was approximately 1/7 that due to differences among spermatozoa. We should note that the specimen analyzed contained a relatively homogeneous population of spermatozoa, as seen by comparing the coefficients of variation in Table 1 with those in Table 5. Thus, we can regard the ratio 1/7 as an upper limit of the relative imprecision of the measurements per spermatozoon.

We can refer to our analysis of repeated sampling

TABLE 4. Results of Variance Components Analysis of Morphometric Parameters from 457 Semen Specimens from 16 Fertile Men*

Summary Statistic	Morphometric Parameter			
	Length (μm)	Width (μm)	Length/Width	Length × Width (μm²)
Mean per ejaculate				
Overall mean value	4.42	2.84	1.58	12.59
Among-donor standard deviation (coefficient of variation)	0.27 (6.0)	0.17 (6.0)	0.12 (7.5)	1.15 (9.1)
Within-donor standard deviation (coefficient of variation)	0.22 (5.0)	0.15 (5.3)	0.07 (4.6)	1.13 (9.0)
Log (standard deviation) per ejaculate				
Overall mean value	0.694	1.225	0.696	1.453
Among-donor standard deviation (coefficient of variation)	0.099 (14.3)	0.111 (9.1)	0.115 (16.5)	0.095 (6.5)
Within-donor standard deviation (coefficient of variation)	0.182 (26.2)	0.186 (15.2)	0.183 (26.3)	0.219 (15.1)

*Ejaculate summary statistics are mean and log (standard deviation). Coefficients of variation are expressed as percentages.

TABLE 5. Comparison of Morphometric Parameters of Spermatozoa from Fertile and Infertile Men*

Summary Statistics	Fertility Status	Morphometric Parameters			
		Length (μm)	Width (μm)	Length/Width	Length × Width (μm²)
Mean	Fertile	4.37 (4.26–4.49)	2.83 (2.77–2.89)	1.56 (1.52–1.61)	12.37 (11.90–12.86)
	Infertile	4.41 (4.23–4.58)	2.68† (2.61–2.75)	1.68† (1.59–1.78)	11.76 (11.28–12.25)
Standard deviation	Fertile	0.579 (0.533–0.629)	0.322 (0.306–0.339)	0.282 (0.264–0.301)	2.185 (2.006–2.380)
	Infertile	0.663 (0.584–0.753)	0.356† (0.335–0.378)	0.358‡ (0.310–0.413)	2.262 (2.076–2.464)
Coefficient of variation	Fertile	0.132 (0.123–0.142)	0.114 (0.108–0.120)	0.181 (0.171–0.192)	0.177 (0.165–0.189)
	Infertile	0.51† (0.137–0.167)	0.133§ (0.124–0.142)	0.213‡ (0.195–0.233)	0.196 (0.179–0.215)

*Values are expressed as the geometric mean (95% confidence limits). The latter were calculated on the log scale, and then transformed back to the linear scale for presentation. L = length; W = width. Statistically significant differences between fertile and infertile men are indicated as: † $P < 0.05$; ‡ $P < 0.01$; § $P < 0.001$.

of 50 spermatozoa per ejaculate (Table 2) to make some general statements about the gain in precision when larger numbers (n) are sampled. In general, we can write

$$CV_n \simeq CV_{50} \sqrt{50/n}$$

where CV_n and CV_{50} are, respectively, the coefficients of variation when n and 50 spermatozoa are sampled per specimen (Rao, 1965). Thus, for example, if n = 200, there is approximately a two-fold reduction in the coefficients of variation. In interpreting the magnitude of the coefficients of variation, a helpful general rule is that the relative difference between a sampling statistic based on a finite number of spermatozoa and the true value for the entire population is extremely unlikely to exceed three coefficients of variation (Deming, 1960). Choice of an acceptable level of precision must be based on technical and logistic considerations, as well as on biomedical ones. Using our methodology, approximately 10 minutes are required to analyze 50 spermatozoa on a single slide.

It is instructive to compare the precision of our morphometric analysis with the sampling precision inherent in traditional morphologic classification. Letting p = percent normal spermatozoa/100, the coefficient of variation for the latter is $\sqrt{(1-p)/np}$, where n is the number of spermatozoa classified (Snedecor and Cochran, 1973). Letting n = 50, the coefficient of variation values 17.3%, 14.1%, 11.5%, and 9.3% are obtained for percent normal values of 40%, 50%, 60%, and 70%, respectively. These values are much larger than the coefficients of variation for the ejaculate means of the morphometric parameters, and are approximately the same size as for the ejaculate standard deviations (Table 2).

When spermatozoa are prepared for morphologic examination, most laboratories use smears in which the cells are dried and stained. Such procedures dehydrate the sperm cytoplasm, and some cell shrinkage is likely to result. The fine details of the staining and/or fixation technique can influence the fine details of sperm morphology (Harasymowycz et al, 1976). Our laboratory uses the Papanicolaou staining technique for human spermatozoa because of its optical advantages, and because it is commonly used by other laboratories in evaluating human semen. Our data confirm that there is a reduction in the dimensions of human sperm heads when assessed with the Papanicolaou stain vs. wet mounts. The dried-stained preparations contained spermatozoa whose heads were, on the average, 30% smaller in the projected area than those in wet preparations. Both head length and width tended to shrink by approximately 15%, so that the aspect ratio did not change appreciably. Within-specimen variability in sperm head dimensions also was reduced by the drying-staining procedure. The standard deviations of head width, projected area, and circumference were, respectively,

39%, 47%, and 25% less in the stained preparations, but the variability of the sperm head aspect ratio did not change significantly, since the compensating shrinkage of length and width was similar in most cells.

Our analysis of repeated ejaculates from fertile donors (Table 4) indicated relatively small within-and among-donor variability for the ejaculate mean values of the morphometric parameters, but somewhat larger variation for the ejaculate log standard deviations. It should be appreciated that the coefficients of variation for the within-donor components of the total variability include contributions due to measurement precision (Table 1) and finite sampling per ejaculate (Table 2). For the sake of simplicity, we have not analytically isolated these contributions. We do note that the purely biologic components of the within-donor variation, however, are somewhat smaller than those given in Table 4.

It is worth noting that for all measurements except length × width both the among-donor and within-donor coefficients of variation were greater for the per-ejaculate standard deviations than for the means. Perhaps natural causes do not act uniformly on all spermatozoa, a conclusion consistent with the results in Table 5. It is also worth noting that the coefficients of variation for the percentage of normal forms were similar in magnitude to those for the standard deviations of the morphometric parameters.

Our analysis of single semen specimens from 30 fertile and 30 infertile men (Table 5) indicates that per-ejaculate variability of the morphometric parameters discriminates between the two groups more effectively than does the per-ejaculate central tendency. A similar conclusion was reached by Schmassmann et al (1979). The data of van Duijn et al (1972) also support this finding, although neither of these previous studies accurately defined the fertility of their participants. As seen in Table 5, the sperm head aspect ratio, length/width, was the single parameter that most effectively distinguished the fertile and infertile groups of men. Sperm head width was the second most effective parameter. It is entirely possible that greater mathematical discrimination between fertile and infertile men can be achieved when new morphometric parameters are derived and/or when the results from different morphometric parameters are combined. The latter approach was taken by Schmassmann et al (1979) with some success. Bartoov et al (1982) combined data on the frequency of occurrence of different morphologic defects, as assessed subjectively. Such combinations improved their ability to discriminate between populations of fertile and "suspected infertile" men. Establishment of a normal range of values for different statistical measures of different morphometric parameters (van Duijn et al, 1972) would aid in the evaluation of seminal sperm morphology. Finally, we note that mathematical transformation of the data also may contribute to the incisiveness of the morphometric approach.

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4th Congress of the French-speaking Society of Andrology

The 4th Congress of the French-speaking Society of Andrology will take place December 19–21, 1986 in Brazzaville, the People's Republic of the Congo, under the patronage of His Excellency, Colonel Denis Sassou-Nguesso, President of the Congo. The program will cover topics on the epidemiology of infertility in Africa, infectious diseases related to male infertility, diabetes and male sexuality, the examination of the infertile male, varicocele, azoospermia, prostatic pathology, and testicular pathology. The cost of attending the Congress for members of the French-speaking Society of Andrology is 750 FF and 900 FF for nonmembers. Contact:

Professor J. C. Czyba
Laboratory of the Biology of Reproduction
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8, Avenue Rockefeller
69373 Lyon Cedex 08, France

Workshop on Regulation of Ovarian and Testicular Function

A 2½ day workshop on "Regulation of Ovarian and Testicular Function" will be held at the Augusta Hilton Hotel, Augusta, Georgia on February 7–9, 1987. The workshop is being organized by a program committee consisting of Drs. Everett Anderson, Dharam Dhindsa, Satya Kalra, and Virendra Mahesh, and will consist of four symposium sessions and one poster session. The symposium sessions will be 1) Neuroendocrine Regulation of Gonadotropin Secretion, 2) Regulation of Corpus Luteum Function in Pregnancy, 3) Regulation of Folliculogenesis and Ovulation, and 4) Regulation of Testicular Cell Functions and Spermatogenesis. Posters are invited from the participants in the area of the workshop on Gonadel Peptides and Growth Factors. One afternoon will be set aside for viewing posters and scientific discussions. The proceedings of the workshop, including short articles from the posters, will be published. The workshop is sponsored by the National Institute of Child Health and the Reproductive Biology Study Section of the Division of Research Grants, National Institutes of Health. Attendance is limited to 250 persons on a first-come, first-serve basis. A detailed program is available. For further details and to reserve a place for the workshop, please write to:

Dr. Virendra B. Mahesh, Chairman
Department of Physiology and Endrocrinology
Medicine College of Georgia
Augusta, Georgia 30912-3395