

Pattern of Semen Parameters among Male Partners of Infertile Couples in Kashmir, India: A Prospective Cross-Sectional Study at a Tertiary Care Hospital

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Abstract

Background: Male factors contribute to about half of all infertility cases, yet semen quality data from the Kashmir valley are scarce. We described the pattern of semen parameters in male partners of infertile couples in Kashmir.

Methods: In this prospective cross-sectional study, 350 consecutive male partners of couples with at least 12 months of infertility were enrolled at Lalla Ded Hospital, Srinagar, over 18 months. Semen was analysed manually according to the World Health Organization (WHO) 2021 manual. The primary endpoint was the distribution of semen diagnostic categories; secondary endpoints were abnormalities of individual parameters, the correlation of sperm concentration with motility, and variation across age groups.

Results: Mean age was 35.79 ± 3.67 years, 56.0% of men were older than 35 years, and mean duration of infertility was 3.49 ± 1.71 years. Normozoospermia was found in 58.6% of men. Asthenozoospermia was the most frequent abnormal diagnosis (17.1%), followed by necrozoospermia (7.7%), azoospermia (7.1%) and oligoasthenoteratozoospermia (4.9%). Progressive motility was low in 33.1% of men and sperm concentration in 14.0%. Sperm concentration correlated with progressive motility ($r = 0.835$) and total motility ($r = 0.856$) and inversely with immotile sperm ($r = -0.856$); all $p < 0.001$. Across age groups, only semen pH ($p = 0.036$) and leukocyte count ($p = 0.014$) differed.

Conclusions: About four in ten men had an abnormal semen profile, driven mainly by impaired motility rather than low sperm output. Semen analysis of the male partner should be part of the first infertility visit in this region.

Keywords: male infertility; semen analysis; asthenozoospermia; sperm motility; WHO 2021; Kashmir; kangri

Introduction

Infertility, the failure to achieve a clinical pregnancy after 12 months or more of regular unprotected intercourse, is one of the most common health conditions of adults in the reproductive age group. A World Health Organization supported meta-analysis of studies published between 1990 and 2021 estimated a lifetime prevalence of 17.5% and a period prevalence of 12.6%, which means that about one in six people are affected at some point in their lives [1]. Male factors, alone or together with female factors, are present in about half of

these couples [2]. The burden is growing. Analysis of the Global Burden of Disease (GBD) 2021 data showed that the age-standardised prevalence of male infertility rose from 2752.5 to 3218.9 per 100,000 between 1990 and 2021, with the heaviest burden in low and middle socio-demographic index regions [3], a trend already visible in the GBD 2019 estimates [4]. At the same time, a meta-regression of samples collected across six continents reported a continuing fall in sperm concentration, with a steeper decline after the year 2000 that now includes men from South America, Asia and Africa [5].

Indian data point in the same direction. The multicentre Indian Male Factor Subfertility Evaluation (IM-FaST) study, which evaluated 2414 infertile couples at 17 tertiary centres, found a male factor alone in 27.3% of couples; asthenozoospermia was the most common semen abnormality (23.4%), and urban residence, heat exposure and lower socioeconomic status independently predicted abnormal semen parameters [6]. In neighbouring Pakistan, azoospermia was recorded in 16.7% of 809 men with male factor infertility at a Karachi referral unit [7]. These figures show that the male contribution is sizeable and that its pattern differs between regions.

In current practice, semen analysis remains the first and often the only laboratory test of the male partner. The sixth edition of the WHO laboratory manual, released in 2021, revised several procedures and stressed that results are comparable across laboratories only when standardised methods are strictly followed [8]. Published patterns vary widely. In Western Ethiopia only 16% of men attending an infertility clinic had entirely normal semen [9], whereas a study from eastern India found that most semen parameters did not differ across age groups [10]. Such differences reflect population structure, age at presentation, lifestyle and environmental exposures, and laboratory technique. Male reproductive ageing adds oxidative damage, falling testosterone and sperm DNA damage to this mix [11], and socioeconomic position and cigarette smoking have both been linked to poorer semen quality [12,13].

The Kashmir valley has distinct climatic, dietary and sociocultural features, and infertility is common here. In the only community-based estimate from the region, a randomised survey of 10,063 married couples, 15% had primary infertility; among 250 couples evaluated for its cause, a male factor was identified in 22.4% and combined male and female factors in a further 5.2% [14]. The authors described primary infertility as “as common and distressing a problem in India as in other parts of the world” and noted that “infertile couples report late for evaluation” [14]. These data are now almost three decades old. Local exposures may also contribute. Through the long winter, many Kashmiris carry a kangri, an earthen pot of burning charcoal encased in wicker, beneath the loose woollen cloak (pheran), close to the abdomen and thighs for long periods. Chronic heat from the kangri is an established cause of erythema ab igne and of a heat-induced squamous cell carcinoma of the thighs and abdominal wall known as kangri cancer [15,16], yet its effect on scrotal temperature and semen quality has never been measured, and no study has examined its effect on female reproductive function. Among women, polycystic ovary syndrome (PCOS) appears common: in a recent survey of 1217 female college students in Kashmir, 29.9% reported a previous diagnosis of PCOS, and a third of the remainder screened at risk [17].

Infertility in this setting also carries a substantial psychological and social burden. A representative survey of 5519 adults across the ten districts of the Kashmir valley estimated that 45% had probable mental distress and 41% probable depression, with higher rates among women and rural residents [18], so infertile couples here face a high background level of distress. A study of 300 Indian men and women with primary infertility found low family acceptance of infertility, high levels of stigma, concealment and discrimination among men, and three-fold greater distress in women whose families held unrealistic expectations of treatment; subfertile individuals were socially perceived as “deprived, blemished, incomplete, and sexually incompetent” [19]. For men, a diagnosis of male factor infertility can threaten identity and masculinity and lead to depression, anxiety and sexual dysfunction, while cultural taboos around semen collection add to the distress [20]. Such stigma helps explain why the male partner is often investigated late or not at all.

Despite this burden, in routine practice in Kashmir the infertility work-up is still centred on the woman, with the male partner often tested late. To our knowledge, no prospective study has described semen quality in Kashmiri men using the WHO 2021 manual. Without local data, clinicians cannot judge how often male factors contribute to infertility in this population, which abnormalities predominate, or where diagnostic effort should be directed.

We therefore conducted a prospective study at the main referral hospital for women in Kashmir. The primary objective was to describe the distribution of semen diagnostic categories among male partners of infertile couples. The secondary objectives were to estimate the frequency of abnormality in individual macroscopic and microscopic parameters, to examine the correlation between sperm concentration and motility, and to compare semen parameters across age groups.

Methods

Study design and setting

This was a prospective cross-sectional observational study, reported in line with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for cross-sectional studies. It was conducted in the Postgraduate Department of Obstetrics and Gynaecology at Lalla Ded Hospital, the tertiary care maternity and gynaecology hospital attached to Government Medical College, Srinagar, which serves as the main referral centre for women across the Kashmir valley. Participants were recruited from the Gynaecology outpatient department, and semen samples were analysed in the dedicated andrology section of the hospital laboratory. The study was completed over 18 months.

Study population

Male partners of couples who had been married and cohabiting for at least 12 months, who reported regular unprotected intercourse during this period, and whose female partners attended the Gynaecology outpatient department with infertility as the main complaint were eligible. Men were included if they were willing to give written informed consent. Men with a documented chronic illness known to affect fertility, such as diabetes mellitus or hypertension, men using drugs or medicines that could impair spermatogenesis or sexual function, men with

previous exposure to radiotherapy or chemotherapy, and men who declined consent were excluded.

Sampling and sample size

Consecutive sampling was used. Every eligible male partner attending during study hours was invited until the target of 350 men was reached. With this number, a proportion close to 50% can be estimated with a margin of error of about 5.2% at the 95% confidence level. All men formed a single cohort, and no fertile control group was recruited.

Study endpoints and definitions

The primary endpoint was the distribution of semen diagnostic categories: normozoospermia, oligozoospermia, asthenozoospermia, teratozoospermia, necrozoospermia, azoospermia and combined defects. Secondary endpoints were the proportion of men with values below the reference limit for each parameter, the correlation of sperm concentration with progressive, non-progressive and total motility and with the proportion of immotile sperm, and the comparison of semen parameters across age groups. The lower reference limits applied were a semen volume of 1.5 mL, pH of 7.2, sperm concentration of 16 million/mL, total sperm count of 39 million per ejaculate, progressive motility of 30%, total motility of 42%, normal morphology of 4% and vitality of 58%; liquefaction within 60 minutes was taken as normal. Oligozoospermia, asthenozoospermia, teratozoospermia and necrozoospermia denoted values below the limits for concentration, progressive motility, morphology and vitality, respectively, and azoospermia the absence of spermatozoa. Age was grouped as below 25, 25 to 30, 31 to 35 and above 35 years.

Semen collection and laboratory analysis

Men were asked to abstain from ejaculation for 3 to 7 days. Samples were produced by masturbation or, where this was not acceptable, by coitus interruptus into a sterile wide-mouthed container, delivered within one hour, liquefied at room temperature and analysed within one hour of collection. All analyses were performed manually by conventional microscopy following the sixth edition of the WHO manual [8].

Volume was measured with a graduated cylinder, appearance was recorded visually, viscosity was judged from thread formation on dropping from a pipette, pH was measured with indicator paper, and liquefaction time was recorded. Sperm concentration was determined with an improved Neubauer haemocytometer after appropriate dilution, with spermatozoa counted at 400x magnification. Motility was assessed on a drop of well-mixed semen at 400x magnification; at least 200 spermatozoa were classified as progressively motile, non-progressively motile or immotile, and each class was expressed as a percentage. For morphology, smears were stained by the Papanicolaou method and at least 200 spermatozoa were examined under oil immersion at 1000x magnification using strict criteria. Sperm vitality was assessed according to the WHO manual. Leukocyte concentration was expressed in million/mL.

Quality control

All samples were analysed by trained laboratory staff using the standard procedures of the WHO manual to limit inter-observer variation.

Data collection and bias

A structured proforma recorded age, duration of marriage and infertility, abstinence period, medical history and laboratory results; data were later entered into a secure electronic database. Consecutive enrolment and a single standardised laboratory protocol were used to reduce selection and measurement bias.

Statistical analysis

Data were analysed with the Statistical Package for the Social Sciences (SPSS), version 20.0. Continuous variables were summarised as mean $\pm$ standard deviation (SD) or median with interquartile range according to their distribution, and categorical variables as frequency and percentage. The association between sperm concentration and each motility measure was assessed with Pearson correlation, and 95% confidence intervals (CI) were derived by Fisher z transformation. Semen parameters were compared across age groups by one-way analysis of variance; because the group below 25 years contained a single participant, it was presented descriptively and was not included in the test. A two-sided p value below 0.05 was taken as statistically significant..

Ethical considerations

The study followed the principles of the Declaration of Helsinki and was approved by the Institutional Ethics Committee of Government Medical College, Srinagar, before recruitment began. All participants gave written informed consent, including consent for publication of anonymised data. Participation was voluntary and refusal did not affect care.

Results

Participant characteristics and macroscopic semen profile

All 350 enrolled men were included in the analysis. Their mean age was 35.79 ± 3.67 years; 196 men (56.0%) were older than 35 years and 120 (34.3%) were aged 31 to 35 years. The mean duration of infertility was 3.49 ± 1.71 years, and every participant observed an abstinence period of 3 to 7 days (mean 5.50 ± 1.13 days). Macroscopic findings were largely within normal limits. Mean semen volume was 2.92 ± 0.64 mL, and only 7 men (2.0%) had a volume below 1.5 mL. All samples had a pH of 7.2 or more and liquefied within 60 minutes. Most samples were greyish-white (62.3%), and the mean seminal leukocyte count was 0.49 ± 0.17 million/mL (Table 1).

Table 1. Demographic, clinical and macroscopic semen characteristics of the study participants (N = 350)

Characteristic	Value
Age (years), mean $\pm$ SD	35.79 $\pm$ 3.67
Age group, n (%)	
Below 25 years	1 (0.3)
25-30 years	33 (9.4)
31-35 years	120 (34.3)
Above 35 years	196 (56.0)
Duration of infertility (years), mean $\pm$ SD	3.49 $\pm$ 1.71
Abstinence period (days), mean $\pm$ SD	5.50 $\pm$ 1.13
Abstinence of 3-7 days, n (%)	350 (100)
Semen volume (mL), mean $\pm$ SD	2.92 $\pm$ 0.64
Semen volume below 1.5 mL, n (%)	7 (2.0)
Semen pH, mean $\pm$ SD	7.57 $\pm$ 0.15
Semen pH 7.2 or above, n (%)	350 (100)
Liquefaction time (min), mean $\pm$ SD	14.28 $\pm$ 2.96
Liquefaction within 60 min, n (%)	350 (100)
Semen appearance, n (%)	
Greyish-white	218 (62.3)
Yellow-white	67 (19.1)
Transparent	65 (18.6)
Seminal WBC (million/mL), mean $\pm$ SD	0.49 $\pm$ 0.17

Data are presented as mean $\pm$ SD or n (%). min, minutes; mL, millilitre; N, total number of participants; SD, standard deviation; WBC, white blood cells.

Microscopic semen parameters

Mean sperm concentration was 42.25 ± 21.06 million/mL and mean total sperm count was 134.05 ± 82.36 million per ejaculate; 49 men (14.0%) fell below the reference limit for each. Motility was the parameter most often abnormal. Progressive motility was below 30% in 116 men (33.1%), with a mean of $35.24 \pm 13.47\%$, and total motility was below 42% in 123 men (35.1%). Normal morphology below 4% was found in 55 men (15.7%), and vitality below 58% in 42 men (12.0%) (Table 2).

Table 2. Microscopic semen parameters and proportion of participants below the lower reference limit (N = 350)

Parameter	Mean $\pm$ SD	Lower reference limit	Below limit, n (%)
Sperm concentration (million/mL)	42.25 $\pm$ 21.06	16	49 (14.0) ^a
Total sperm count (million/ejaculate)	134.05 $\pm$ 82.36	39	49 (14.0) ^a
Progressive motility (%)	35.24 $\pm$ 13.47	30	116 (33.1)
Non-progressive motility (%)	12.00 $\pm$ 4.64	NA	NA
Total motility (%)	47.24 $\pm$ 17.00	42	123 (35.1)
Immotile spermatozoa (%)	52.76 $\pm$ 17.00	NA	NA
Normal morphology (%)	9.95 $\pm$ 5.54	4	55 (15.7)
Vitality (%)	67.39 $\pm$ 8.63	58	42 (12.0)

^aIncludes the 25 men with azoospermia. Values below the limits for concentration, progressive motility, normal morphology and vitality correspond to oligozoospermia, asthenozoospermia, teratozoospermia and necrozoospermia, respectively. N, total number of participants; NA, not applicable (no lower reference limit defined); SD, standard deviation.

Distribution of semen diagnostic categories

Normozoospermia was found in 205 men (58.6%). Asthenozoospermia was the most frequent abnormal diagnosis, seen in 60 men (17.1%), followed by necrozoospermia in 27 (7.7%) and azoospermia in 25 (7.1%). Among combined defects, oligoasthenoteratozoospermia was the most common (4.9%). Isolated oligozoospermia (0.3%) and isolated teratozoospermia (0.6%) were rare. Taken together, a motility defect, alone or with other abnormalities, was present in 89 men (25.4%) (Table 3).

Table 3. Distribution of semen diagnostic categories among male partners of infertile couples (N = 350)

Semen diagnosis	n	%
Normozoospermia	205	58.6
Asthenozoospermia	60	17.1
Necrozoospermia	27	7.7
Azoospermia	25	7.1
Oligoasthenoteratozoospermia	17	4.9
Asthenoteratozoospermia	9	2.6
Oligoasthenozoospermia	3	0.9

Semen diagnosis	n	%
Teratozoospermia	2	0.6
Oligozoospermia	1	0.3

Percentages are calculated on the total of 350 participants. Categories were assigned using the lower reference limits given in the Methods: sperm concentration 16 million/mL, progressive motility 30%, normal morphology 4% and vitality 58%. N, total number of participants.

Correlation between sperm concentration and motility

Sperm concentration showed a strong positive correlation with progressive motility ($r = 0.835$, 95% CI 0.800 to 0.864; $p < 0.001$) and total motility ($r = 0.856$, 95% CI 0.825 to 0.881; $p < 0.001$), a moderately strong positive correlation with non-progressive motility ($r = 0.710$; $p < 0.001$), and a strong negative correlation with the proportion of immotile spermatozoa ($r = -0.856$; $p < 0.001$) (Table 4).

Table 4. Correlation of sperm concentration with motility parameters (N = 350)

Sperm concentration versus	Pearson r	95% CI	p value
Progressive motility	0.835	0.800 to 0.864	<0.001
Non-progressive motility	0.710	0.654 to 0.759	<0.001
Total motility	0.856	0.825 to 0.881	<0.001
Immotile spermatozoa	-0.856	-0.881 to -0.825	<0.001

CI, confidence interval; N, total number of participants; r, Pearson correlation coefficient.

Semen parameters across age groups

Across the three age groups with adequate numbers (25 to 30, 31 to 35 and above 35 years), mean values of volume, sperm concentration, total sperm count, motility, morphology and vitality did not differ significantly. Semen pH was slightly higher in men aged 25 to 30 years (7.63 ± 0.16) than in men aged 31 to 35 years (7.58 ± 0.14) and above 35 years (7.56 ± 0.15 ; $p = 0.036$), and the seminal leukocyte count was higher in the youngest of these groups (0.57 ± 0.18 versus 0.48 ± 0.16 and 0.48 ± 0.17 million/mL; $p = 0.014$). The single participant below 25 years is shown for completeness (Table 5).

Table 5. Semen parameters across age groups

Parameter	Below 25 years (n = 1)	25-30 years (n = 33)	31-35 years (n = 120)	Above 35 years (n = 196)	p value ^a
Volume (mL)	1.18	2.77 ± 0.61	2.97 ± 0.58	2.93 ± 0.67	0.278
pH	7.60	7.63 ± 0.16	7.58 ± 0.14	7.56 ± 0.15	0.036

Parameter	Below 25 years (n = 1)	25-30 years (n = 33)	31-35 years (n = 120)	Above 35 years (n = 196)	p value ^a
Liquefaction time (min)	11.00	13.64 ± 3.27	14.05 ± 2.62	14.55 ± 3.09	0.143
Sperm concentration (million/mL)	75.10	36.65 ± 17.48	42.82 ± 20.38	42.67 ± 21.89	0.287
Total sperm count (million)	88.60	110.96 ± 68.82	138.00 ± 81.11	135.76 ± 85.06	0.230
Progressive motility (%)	30.90	32.28 ± 14.44	35.93 ± 13.37	35.34 ± 13.40	0.385
Non-progressive motility (%)	35.00	10.63 ± 3.93	12.04 ± 4.42	12.09 ± 4.59	0.213
Total motility (%)	65.90	42.91 ± 16.79	47.97 ± 16.95	47.43 ± 17.04	0.304
Immotile spermatozoa (%)	34.10	57.09 ± 16.79	52.03 ± 16.95	52.57 ± 17.04	0.304
Normal morphology (%)	16.00	8.25 ± 4.66	10.29 ± 5.38	10.00 ± 5.73	0.167
Vitality (%)	59.70	66.24 ± 8.97	67.68 ± 8.83	67.44 ± 8.49	0.697
WBC (million/mL)	0.09	0.57 ± 0.18	0.48 ± 0.16	0.48 ± 0.17	0.014

Values are mean ± SD; for the group below 25 years the single observed value is shown. ^aOne-way analysis of variance across the 25-30, 31-35 and above 35 year groups; the group below 25 years (n = 1) was excluded from testing. Bold p values indicate statistical significance (p < 0.05). min, minutes; mL, millilitre; SD, standard deviation; WBC, white blood cells.

Discussion

In this prospective study of 350 male partners of infertile couples in Kashmir, 41.4% of men had an abnormal semen profile. The abnormalities were mainly functional: asthenozoospermia was the leading diagnosis, and one in three men had low progressive motility, whereas low sperm output and macroscopic abnormalities were far less common. Sperm concentration and motility were closely correlated, and within the narrow age range of this cohort, age had little effect on conventional semen parameters.

Turning to the primary objective, the proportion of normozoospermic men (58.6%) was higher than in several recent reports. Only 16% of men in Western Ethiopia had entirely normal semen [9], and normozoospermia was almost absent among Pakistani men in whom male factor infertility had already been identified [7]. Our figure is closer to the multicentre Indian IM-FaST study, in which a male factor alone accounted for 27.3% of infertile couples [6]. Three

features of our design probably explain the difference. First, we recruited every male partner of couples attending a gynaecology clinic, not men referred to an andrology service because of a suspected male problem, so our sample reflects the full spectrum of couples rather than a pre-selected group. Second, men with chronic illness, gonadotoxic treatment or drugs affecting spermatogenesis were excluded. Third, the reference limits of the WHO 2021 manual for concentration and motility are lower than those of earlier editions, so fewer men are classified as abnormal than in older studies [8]. Normozoospermia on a single sample does not establish normal fertility potential.

Asthenozoospermia was the most common abnormal category (17.1%), and a motility defect was present in a quarter of all men. This agrees with the IM-FaST study, where asthenozoospermia was also the most frequent abnormality (23.4%) [6], and with the Ethiopian series, where asthenozoospermia affected 43.5% [9]. The biological explanation lies in how motility is generated. Forward movement depends on adenosine triphosphate produced by the mitochondria of the midpiece and on an intact flagellar axoneme. Reactive oxygen species from leukocytes, immature germ cells and external exposures attack the polyunsaturated fatty acids of the sperm membrane, disrupt the mitochondrial electron transport chain and reduce energy supply, so that motility is often the first function to fail even when sperm numbers are preserved [21]. In Indian men, heat exposure, urban residence and lower socioeconomic status independently predicted abnormal semen parameters [6], socioeconomic disadvantage has been linked to poorer semen quality in other populations [12], and smoking has been associated with lower semen quality and higher sperm DNA fragmentation [13]. In Kashmir, the kangri is a plausible local source of scrotal heat. Spermatogenesis proceeds optimally at a temperature slightly below that of the body core, and testicular heat stress causes germ cell apoptosis, DNA damage and poorer sperm quality [22]. In normozoospermic volunteers, two 15-minute sauna sessions a week for three months caused a marked fall in sperm count and motility and impaired sperm mitochondrial function, changes that reversed within six months of stopping exposure [23]. Daily kangri use through a winter of several months is a far more prolonged exposure, and its chronic thermal injury to the skin of the abdomen and thighs is well documented [15,16]. A heat effect would fit the motility-dominant pattern seen here, but kangri use and season of sampling were not recorded in this study, so this hypothesis needs direct testing with exposure histories and, ideally, scrotal temperature measurement.

Necrozoospermia was the second most common diagnosis (7.7%), and 12.0% of men had vitality below the reference limit. This is higher than expected for a condition usually described as uncommon and poorly documented [24]. Distinguishing live immotile spermatozoa from dead spermatozoa matters because the two point to different causes and treatments, and the WHO manual recommends vitality testing when total motility is low [25]. Necrozoospermia has at least 12 recognised causes, including genital tract infection, varicocele, heat exposure, prolonged abstinence and antisperm antibodies, and many of them are correctable [26]. Pre-analytical factors may also have contributed: samples transported in the cold Kashmiri winter or obtained by coitus interruptus are exposed to temperature change and contamination that can lower vitality, and repeat testing under controlled conditions would help separate true necrozoospermia from artefact.

Azoospermia was found in 7.1% of men, lower than the figure of up to 15% commonly quoted for infertile men [27] and well below the 24% reported in Ethiopia [9] and 16.7% in Karachi [7]. Two design choices explain much of this gap: we excluded men with previous chemotherapy or radiotherapy, and severe cases tend to concentrate in andrology referral clinics rather than in a gynaecology outpatient setting. Non-obstructive azoospermia reflects failure of spermatogenesis, often with a genetic basis such as Klinefelter syndrome or Y chromosome microdeletions, and these men need hormonal and genetic evaluation before sperm retrieval and intracytoplasmic sperm injection are considered [27].

Normal volume, pH and liquefaction in almost all samples suggest preserved seminal vesicle and prostatic function and make ejaculatory duct obstruction an unlikely cause of infertility in this cohort. The mean leukocyte count of 0.49 million/mL was below the conventional threshold of 1 million/mL. The relation between seminal leukocytes and semen quality in infertile men is still debated [28], but our data suggest that overt genital tract inflammation was not the main driver of the motility defects seen here, although leukocytes at lower concentrations can still generate reactive oxygen species [21].

For the secondary objectives, sperm concentration correlated strongly with progressive and total motility and inversely with the proportion of immotile spermatozoa. The same testicular and epididymal processes govern both how many spermatozoa are produced and how well they move: Sertoli cell support, the hormonal environment and epididymal maturation all shape sperm number and flagellar competence together [2]. Oxidative stress damages developing germ cells as well as mature spermatozoa, so a single insult can reduce both output and motility [21]. A statistical point also needs stating. Azoospermic and severely oligozoospermic samples contribute values at or near zero for both variables, which strengthens a Pearson correlation. The coefficients therefore describe the whole cohort and do not show that motility rises with concentration among men with normal counts.

Across age groups we found no significant differences in volume, concentration, motility, morphology or vitality. This matches the eastern Indian study, in which volume, motility and morphology did not differ across age groups [10]. Longitudinal data from infertile men show that declines in volume, motility and morphology become evident mainly over intervals longer than five years [29], and a large recent cohort linked advancing age with poorer sperm quality and DNA integrity [30]. The mechanisms include cumulative oxidative damage, declining testosterone and accumulating sperm DNA damage [11], changes that tend to become measurable after the age of 40. Our cohort was concentrated in a narrow band (SD 3.67 years), with few men in their forties, and conventional semen analysis does not capture DNA damage; both features limit the ability to detect an age effect. The small differences in pH (0.07 units) and leukocyte count across groups have little clinical meaning and, given the number of comparisons made, may be due to chance.

The male partner should undergo semen analysis at the first infertility visit rather than after the woman has been investigated, since four in ten men in this cohort had an abnormal result after an average of three and a half years of infertility. Because motility and vitality defects predominate, laboratories should apply vitality testing whenever motility is low [25], and clinicians should look for correctable causes such as infection, varicocele, heat exposure and

smoking [13,26]. Men with azoospermia need structured endocrine and genetic assessment [27]. These data also provide a local baseline for auditing standardised laboratory practice [8]. Clinical care should also address the psychosocial burden of infertility. Given the high background of mental distress in the valley [18] and the stigma attached to infertility, particularly to male infertility [19,20], presenting semen analysis as a routine test for both partners, providing private and culturally acceptable facilities for semen collection, and screening both partners for depression and anxiety, with referral where needed, may reduce both delay and distress. Counselling should include practical advice on avoiding prolonged heat exposure to the groin, including from the kangri, and on stopping smoking.

The study has limitations. It was conducted at a single hospital, and although consecutive sampling reduced selection bias, the results may not apply to men attending other services. Each man provided one semen sample, while semen parameters vary within the same individual. No fertile control group was included, and lifestyle factors such as kangri use and smoking, occupation, body mass index, varicocele, reproductive hormones and female factors were not recorded, so causes could not be assigned. Psychological distress and experience of stigma were not assessed. Advanced tests such as sperm DNA fragmentation and oxidative stress markers were not performed. Collection by coitus interruptus was permitted for some men, and the cut-offs used for volume and vitality followed the earlier WHO edition; both may have influenced the classification of a minority of samples. Only one participant was younger than 25 years, which prevented meaningful analysis of that group.

Conclusion

In this cohort of male partners of infertile couples in Kashmir, about four in ten men had an abnormal semen profile. Impaired motility, rather than reduced sperm production, was the dominant abnormality, followed by low vitality and azoospermia, while macroscopic parameters were largely normal. Sperm concentration and motility were closely linked, and age had little effect within the range studied. Early semen analysis of the male partner, vitality testing when motility is low, and targeted evaluation for correctable causes should form part of routine infertility care in the region. Multicentre studies with repeat sampling, lifestyle and environmental data, including kangri exposure, and sperm functional tests are needed to explain the motility-dominant pattern observed here.

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