

Seasonal variation of semen quality and fertility

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At many locations in the northern hemisphere human sperm counts are reduced during the summer. Experiments with rhesus monkeys suggest that such seasonal variation may be induced by an endogenous biological clock reset annually by changes in the length of daylight. Little is known about seasonal variation in human female reproductive function, although fecundity may be lower during the summer, as it is for men. Variation in fecundity could help explain seasonal patterns of birth in countries such as the United States, where there is a deficit of spring births. But the relationship to patterns of birth in Canada and Europe, where the birth rate is highest during late winter and spring, is unclear.

Key terms biological clock, births, human, photoperiod, light, season, sperm count.

In recent years concern about the potential of chemicals to cause reproductive toxicity has increased in industrialized countries. The trend to delay marriage and child-bearing has focused attention on infertility and its possible relationship to occupational and environmental exposures.

Little is truly known about the effects of chemical exposures or the effects of other environmental or life-style factors on human male reproductive capacity. So-called “positive” studies linking chemical exposure to reduced semen quality are generally unconvincing in the absence of dramatic effects, such as occurred among workers exposed to the nematocide dibromochloropropane (1). This situation is largely due to deficiencies in our knowledge about the sources of variability in human semen quality.

Not only are differences between populations not understood, but the factors responsible for the profound variation in sperm production within the same person are also largely unknown. In the absence of such information, small differences between exposed and reference groups that might have been explained by an associated

“confounding” factor may be attributed erroneously to chemical exposure.

In most mammalian species there is a period, usually corresponding to the mating season, when spermatogenic and androgenic functions of the testes are maximally developed. At other times these functions regress. If the functions of the human testes also wax and wane with the seasons, causing variation in semen quality and coital frequency, season would then explain some of the variation in sperm production within and between men.

Retrospective studies of semen quality in four seasons

Twenty-nine studies of annual variation in semen quality were identified through searches of the *Index Medicus*; the computerized data bases Biosis, Science Citation Index, and Embase from the mid-1980s through July 1993,(2) and Medline from 1980 through July 1997. Investigations in which data had been obtained over a period exceeding 1 year were collapsed to a single set of 12 months. So that random fluctuations, which may be especially great for sperm counts, could be minimized, only studies with an average of 75 specimens or more

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per month were considered. In 2 cases in which the subjects had contributed many specimens (29 and 74 per person, respectively) the criterion was relaxed to 50 specimens per month since the variation for one person is much less than between persons.

Eighteen studies were excluded because of insufficient specimens, absence of data for 3 or more months, or insufficient published data to estimate values over 3-month periods corresponding to seasons.

Eleven studies were included in the analysis of seasonal variation (3—12 and unpublished data: Levine RJ, Brown MH, Mathew RM, Pattinson HA, Mortimer D. Seasonal variation in semen quality at a Calgary fertility clinic), of which 10 reported values for sperm concentration (table 1). In all 10 studies sperm concentration was lowest during the summer season (July, August, September). The lowest monthly sperm concentration usually occurred during August or September (table 1). Sperm concentration was highest in the fall and winter, with the highest monthly values in February and March. The extent of the summer reduction in sperm concentration was similar for studies conducted above 45° latitude [Edinburgh (6), Lille (9), Basel (10), Calgary (unpublished data: Levine RJ, Brown MH, Mathew RM, Pattinson HA, Mortimer D. Seasonal variation in semen quality at a Calgary fertility clinic)] and those conducted at lower latitudes [New York (4, 7), Houston (5), New Orleans (8)] (2). No consistent seasonal pattern was observed for ejaculate volume, percentage of motile sperm, or percentage of morphologically normal sperm.

Prospective studies of semen quality in summer and winter

Although retrospective studies have indicated a reduction of semen quality during the summer, one might wonder if this could have resulted from differences in the men contributing specimens, in the laboratory procedures, or in other confounding factors in different seasons, rather than from climatic changes. These concerns vanished

after 2 prospective studies of semen quality were published in which specimens were obtained in summer and winter from the same men. The laboratory procedures and technicians were identical in both seasons, and the data were adjusted for potential confounding characteristics.

One of the studies, conducted in San Antonio, Texas, used computer-assisted videomicrography to compare specimens obtained in August and the following February from men who worked outdoors at least 4 hours daily (average 8 hours) (13). The other study, conducted in New Orleans, Louisiana, employed manual methods to compare specimens collected in July and August with those obtained the following January and February (14). In addition, this study contrasted men who worked outdoors at least 4 hours daily (average 7.5 hours) with men who worked indoors in climate-controlled buildings. After adjustment for potential confounders, including abstinence, the first study found a 32% reduction in sperm concentration during the summer relative to winter values. Adjusted results of the 2nd study indicated summer reductions of 19% in sperm concentration and of 13—15% in spermatozoa with normal morphology. There was no difference between indoor and outdoor workers. In both studies the volume of seminal fluid, the percentage of motile sperm, the characteristics of sperm movement, and the reported length of abstinence did not differ significantly between summer and winter.

Discussion

There is little doubt that, at many locations in the northern hemisphere, human semen quality varies with season. Sperm concentration is greatest during fall and winter and least during the summer. There may also be a summer reduction in the proportion of sperm with normal morphology.

What causes these seasonal changes in semen quality? Climatic heat and the intensity of illumination are probably not important factors. In the prospective study of semen quality in San Antonio, the summer sperm

Table 1. Studies included in the retrospective analysis of seasonal variation in human semen quality. (Infert. = infertility)

Reference	Location	Specimens (N)	Donors (N)	Duration (months)	Abstinence (h)	Donor type	Month of lowest sperm count
Hotchkiss, 1941 (3)	New York	642	22	14	>72	Volunteers	---
MacLeod & Heim, 1945 (4)	New York	591	8	10	>72	Students	August
Tjoa et al, 1982 (5)	Houston	4435	4435	52	Unspecified	Prevasectomy	September
Mortimer et al, 1983 (6)	Edinburgh	1566	1566	60	>72	Infert.clinic	August
Spira, 1984 (7)	New York	1067	52	36	Unspecified	Students	September
Levine et al, 1988 (8)	New Orleans	1155	900	37	48-96	Infert.clinic	June
Saint Pol et al, 1989 (9)	Lille	4169	?100	96	48	Sperm donors	October
Politoff et al, 1989 (10)	Basel	2677	?	12	72	Infert.clinic	September
Levine et al (unpublished data, 1990)	Calgary	3601	2191	46	72	Infert.clinic	August
Campaniello et al, 1990 (11)	Bologna	2405	?	52	48-168	Infert.clinic	August
Fisch et al, 1997 (12)	Minnesota	1972	660	288	Unspecified	Prevasectomy	September

concentration and the summer-winter concentration difference were not correlated with the number of summer hours per day at work. Nor were there differences in the extent of reduction of semen quality during the summer between men who worked indoors in New Orleans in air-conditioned surroundings and those who worked outdoors. Furthermore, retrospective studies have suggested a summer reduction in sperm concentration even in Edinburgh (6) and Lille (9), where summer temperatures are moderate and sunlight less intense. The extent of the summer reduction in sperm concentration was similar, moreover, in studies performed at higher or lower latitudes.

Experiments with rhesus monkeys suggest that the seasonal changes in semen quality may be driven by an inherent circannual biological clock reset annually by seasonal changes in the length of daylight. Under laboratory conditions testis volume increases after exposure to short days (8 hours of light, 16 hours of dark) and decreases after exposure to long days (16 hours of light, 8 hours of dark), with concomitant increases and decreases in plasma testosterone, respectively (15). A circannual pattern of pituitary and testicular function was observed even after 4 years under controlled conditions, with nearly constant photoperiod and temperature (16).

Seasonal variation in female reproductive function has also been demonstrated for rhesus monkeys. The incidence of menstruation is greatest in winter (83%/month) and lowest in summer (27%/month). Menstrual cycle length is shorter from December through April (31 days) and longer from June through October (57 days) (17). The number of oocytes harvested from exposed follicles and the rate of maturation in vitro is much greater during October through January (18). While from an evolutionary perspective nonhuman primates are close to humans, the relevance of seasonal changes in the fecundity of rhesus monkeys to humans is uncertain. Unlike humans, rhesus monkeys are seasonal breeders, and they exhibit marked seasonal changes in male and female reproductive function.

There are suggestions that human female reproductive function may also vary seasonally, although a consistent pattern is not apparent. Prolonged menstrual cycles thought to be anovulatory were more likely to occur during summer in adolescent residents of a New York City orphanage (19). A study of donor inseminations in Louisville, Kentucky, using frozen semen specimens quarantined for a minimum of 6 months reported decreased pregnancy rates during spring and late fall (20). Since the semen specimens had been frozen and quarantined, it is likely that the seasonal variation observed reflects seasonal differences in female fecundity. A Dutch investigation of women treated with in vitro fertilization found that the numbers of harvested eggs, fertilized eggs, good embryos, and the pregnancy rate were lowest in

September, July-September, July-October, and July-September, respectively (21). Even though the hypothalamic-pituitary-ovarian function of the women who underwent in vitro fertilization was chemically suppressed and manipulated by exogenous hormones, the difference in the number of harvested eggs suggests a seasonal variation in female fecundity. Differences in the number of fertilized eggs and good embryos and in the pregnancy rate could reflect differences in male or female factors.

Although male and perhaps female fecundity may be reduced during the summer, the relevance of seasonal variation in fecundity to seasonal variation in births is not clear. Persistent seasonal patterns of births have been observed in virtually all human populations, but these patterns differ considerably in different geographic locations. For example, in the southern United States, there is a marked decline in births during April and May, a pattern which is consistent with a summer reduction in fecundity. However in Canada and in northern Europe births increase substantially during March and April (22). Is the seasonal variation in fecundity in Canada and northern Europe overwhelmed by a more marked variation in coital frequency or in noncontracepted intercourse, or are there in fact different seasonal patterns of fecundity in different geographic regions, despite the summer reductions suggested here? It is possible that important new determinants of fertility will be discovered through investigations into the nature and physiological causes of seasonal variation in fecundity and fertility. This information may one day help physicians assist couples desiring to achieve or to prevent pregnancy.

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