How do environmental cues affect male reproduction?

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The effect of season on reproduction

Reproduction is energetically expensive. While the physiological cost is primarily born by the mother, males of many species use considerable energy both to mate and to aggressively prevent other males from mating. As an adaptation to these high energy costs, mating of many species is restricted to a specific mating season. The timing of this season insures that females have a maximal food supply during the most energetically expensive periods of late pregnancy and lactation. For example, wild sheep living in Northern latitudes breed in the fall and lambs are born in the spring. For males, a breeding season restricts their reproductive energy costs to the time of year when females are fertile. The onset of the breeding season has specific physiological underpinnings and in the male, it is associated with activation of the hypothalamic-pituitary-testis axis (Chapter 2). Thus, the synchronization of this axis to specific environmental cues is important to male reproduction in many species.

Obviously, modern humans are not seasonal breeders. Nonetheless, there is evidence that environmental cues play a role in our reproductive biology. In the Southern United States, numbers of births is highest in July through September and lowest in March through May. Thus, conceptions peak in October through December. This seasonal reproductive cycle is less pronounced in the more Northern of the United States, indicating a diminution in the intensity of the environmental cues affecting human reproduction. In contrast, in Finland, Denmark, Austria, Syria and England number of births peak in January through April. However, over the past 500 years, there has been a marked diminution in the seasonal changes in English birth rates. This suggests that humans' increasing control over their living environments is reducing the impact of natural environmental cues.

The three relevant environmental cues are day-length, temperature and availability of food and water. The importance of specific cues undoubtedly varies between different geographic locations. In more Northern latitudes, day-length changes markedly and humans living North of the Artic Circle experience days of constant darkness in the winter and days of constant light in the summer. In the tropics, day length is essentially constant but seasonal changes in rainfall can have a profound effect on food supply of some indigenous peoples and consequently, their reproductive function. In the Southern United Stages, high ambient summer temperatures may be

responsible for the trough in conceptions that occurs in June, July and August.

Seasonal changes in male reproductive function

There are major changes in serum gonadotropin levels and testis function of seasonally breeding animals. In male Rhesus monkeys, serum LH and testosterone levels are increased 4 to 5-fold during the winter breeding season and testis size and sperm production are doubled. Other species show even greater seasonal changes in testis function. For example, with completion of the breeding season for Roe deer, sperm production gradually decreases to zero and testosterone levels fall by more than 95 percent.

There is also evidence that season influences serum levels of LH and testosterone of men. One study reported that in Seattle, the serum concentrations of testosterone and LH in men were highest in June and July and lowest in August and September. In contrast, serum LH levels in Norwegian men dipped in December and this seasonal decline was greater in men living North of the Artic Circle. However, serum testosterone levels in Norwegian men were not reduced in December, emphasizing the disparate effects of seasonal cues on reproductive function of the human male.

Melatonin as a mediator of day-length on male reproduction

As noted above, a substantial change in day-length is a potentially important environmental cue for seasonal breeders. These cues are first detected by the retina and then interpreted by the circadian pacemaker of the brain. A series of nerves connect this pacemaker to the pineal gland, which in humans is found between the cerebral cortex and the cerebellum. The pineal transduces day-length information from the pacemaker by altering its diurnal secretion of the hormone, melatonin. In seasonally breeding animals, melatonin secretion is suppressed by long days and changes in serum melatonin levels can significantly affect reproductive function. However, the nature of the effect depends on whether the animals breed in the winter or in the spring and summer. For example, when male arctic foxes, who breed in the winter, were implanted with melatonin pellets during the arctic summer, the initiation of the winter rise in serum testosterone levels was advanced by two months and the testicular regression that normally occurred with the end of the breeding season was blocked. In contrast, melatonin caused regression of testes of Djungarian hamsters that were simultaneously exposed to stimulatory effects of long day-lengths. The mechanism of action of melatonin in mammals has not been completely defined. However, in specific experimental models, melatonin can increase GnRH secretion, suppress LH secretion or suppress gonadotropin-stimulated steroidogenesis.

In contrast to what has been established for seasonally breeding animals, a role for melatonin in seasonal changes in human male reproduction has not been established. Changes in day-length affect the secretion of melatonin in only a subset of humans and to date, there has been no convincing evidence that a sustained increase in serum melatonin levels affects serum LH or testosterone levels in men.

Heat has a direct inhibitory effect on spermatogenesis

Elevated temperatures are deleterious to sperm production. Heating the human scrotum to 43°C for 30 minutes was shown to cause a significant increase in germ cell death and an 80% decrease in the numbers of sperm in the ejaculate. Conversely, a 12-week course of overnight scrotal cooling was reported to increase numbers of sperm in the ejaculates of men with otherwise low sperm counts. The deleterious effects of heat have also been noted in retrospective study of bakers and welders where it was concluded that occupational heat exposure was a risk factor for human male infertility. Tight underwear, riding a bicycle and sitting with a lap top computer on one's lap all increase scrotal temperature and thus, potentially, the temperature of the testis.

Summary

Environmental cues affect reproductive capacity of males of a number of species. Seasonal changes in numbers of human births suggest that such cues can also affect the reproductive biology of men. The dramatic changes in day-length experienced in more Northern latitudes and prolonged elevated temperatures experienced in Southern latitudes as well as in some industrial work places may affect serum levels of essential reproductive hormones as well as the production of viable male gametes.

Suggested reading

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Handbook of Andrology – How do environmental cues affect male reproduction?

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