Effect of high environmental temperature on semen parameters among fertile men

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Objective: To evaluate the effect of high environmental occupational temperature on semen parameters of fertile men.
Design: Prospective.
Setting: Steel-casting plant.
Patient(s): Ninety fertile workers exposed to a high temperature compared with 40 fertile workers working under ordinary conditions as control subjects.
Intervention(s): Measurement of scrotal temperature by invagination thermometry, air temperature, relative humidity by aspirated psychrometer, radiant heat by globe thermometer, air velocity by light vane anemometer, and semen analysis.
Main Outcome Measure(s): Scrotal temperature and semen analysis.
Result(s): Nonsignificant difference was found between the two groups regarding their scrotal temperature. Also, nonsignificant differences were demonstrated regarding semen analysis parameters being in the normozoospermic range.
Conclusion(s): Under high environmental temperature, semen parameters were within normozoospermic levels owing to body acclimatization mechanisms. (Fertil Steril® 2010;93:1884–6. ©2010 by American Society for Reproductive Medicine.)

Key Words: Testis, heat, semen, male infertility

For normal spermatogenesis to proceed, the scrotal temperature should be 2.2°C lower than the intra-abdominal temperature, which is necessary for spermatogenesis and maturation of spermatozoa. Many studies have shown that elevated intratesticular temperature had adverse affects on spermatogenesis and that extrinsic thermal stress to the scrotum could cause alterations in semen reflecting spermatogenic damage (1–3).

It has also been shown that elevated testicular temperatures by 1°C–1.5°C in two experimental species of mammals resulted in some reduction in testis size, lower sperm production, and production of some abnormal forms (4). Nakamura et al. (5) suggested that slight variation of the testicular temperature may cause spermatogenic dysfunction because of delicate temperature sensitivity of testicular DNA synthesis, with temperature maximal sensitivity at 31°C, whereas for RNA and protein syntheses the maximal sensitivity is 37°C–40°C. Hjollund et al. (6) reported negative correlation between high scrotal temperature and sperm output, with a 40% decrease per 1°C increment of median daytime scrotal temperature. However, Wang et al. (7) concluded that raising scrotal temperature by 0.8°C–1.0°C did not affect spermatogenesis or sperm function. Paul et al. (8) found evidence that the production of sperm containing damaged DNA can be the result of suboptimal DNA repair and/or a mild environmental insult, such as heat stress.

The adverse influence of heat on sperm production has been suggested to lead to oligozoospermia, asthenozoospermia, and teratozoospermia (9, 10). Dyers, cooks, blast furnace workers, and men with varicocele are known to develop testicular hyperthermia, which could lead to oligoasthenoteratozoospermia. Dada et al. (11) reiterated that high intratesticular temperature causes partial or complete spermatogenic arrest and may lead to increased production of morphologically abnormal sperm with impaired sperm motility. Mieusset and Bujan (2, 12) suggested that a daily mild increase in testis temperature could be a potential contraceptive method for men.

Bonde and Storgaard (13) indicated that several occupational hazards to male reproductive function are known, but exposure prevalence is not sufficient to play a role for reduced sperm count in the general male population. Hjollund et al. (14) showed that work position is an important determinant of testicular temperature. Jung and Schuppe (3) concluded that studies addressing professional exposure to high temperatures delivered conflicting results regarding fertility parameters.

The present work aimed to study the effect of high environmental temperature on semen among fertile exposed workers.

MATERIALS AND METHODS

The subjects of this study were selected among two groups of fertile workers with matched age in an iron and steel factory

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TABLE 1

Data of studied groups, mean ± SD (range).

	Study group (n = 90)	Control subjects (n = 40)
Male age (y)	31.88 ± 3.88 (20–40)	32.6 ± 4.28 (26–40)
Marital duration (y)	7.14 ± 4.14 (1–17)	7.4 ± 5.98 (2–20)
Wife age (y)	27.2 ± 3.1 (19–38)	26.8 ± 2.2 (21–37)
No of children	2.66 ± 1.47 (1–5)	2.55 ± 1.28 (1–5)
Work duration (y)	9.5 ± 2.29 (6–13)	9.4 ± 4.01 (3–18)
Heat exposure (h/d)	5.2 ± 0.9 (4–6)	-
Body temperature (°C)	37.04 ± 0.15 (36.7–37.3)	37.07 ± 0.14 (36.9–37.2)
Scrotal temperature (°C)	34.48 ± 0.27 (34–35)	34.38 ± 0.22 (34–34.5)
Difference between body and scrotal temperatures	2.58 ± 0.22 (2–3)	2.69 ± 0.2 (2.4–3.2)
Semen parameters		
Semen volume (mL)	2.9 ± 0.36 (2.5–3.5)	3.3 ± 0.46 (2.4–4.0)
Sperm count (million/mL)	64.1 ± 14.9 (42–85)	69.5 ± 9.72 (47–110)
Sperm motility (%)	68.2 ± 13.01 (50–70)	71.5 ± 5.87 (65–80)
Sperm abnormal forms (%)	9.18 ± 2.2 (8–13)	7.9 ± 3.4 (6–13)

Momen. High temperature and semen parameters. Fertil Steril 2010.

after Institutional Review Board approval. Group 1 included 90 workers from the continuous steel-casting plant, where exposure to heat occurs for about 5 hours. Group 2 included 40 workers from other departments not exposed to heat as control subjects. Inclusion criteria were having children >2 years and absence of varicocele. They were subjected to history taking, including detailed occupational history, type, intensity, and duration of exposures. General and genital examinations were carried out, including measurement of scrotal temperature by invagination thermometry. Two semen analyses were carried out for each case 2 weeks apart. Ejaculates were obtained after 4 days of sexual abstinence. The samples were examined immediately after liquefaction according to World Health Organization guidelines (15). Sperm abnormal forms were examined according to Kruger's strict criteria (16).

Environmental studies for measuring air temperature, humidity, globe temperature, and air velocity were carried out. Air temperature and relative humidity were determined by the use of aspirated psychrometer and psychrometric chart as described by Strydom (17). Radiant heat was measured by using globe thermometer, and air velocity was measured by a light vane anemometer (18). The measurements were as follows: dry bulb temperature 35°C, wet bulb temperature 28°C, humidity 57%–58%, natural wet bulb temperature (NWB) 32°C, globe temperature (GT) 55°C, air velocity 0.3 m/s. Wet bulb globe temperature (WBGT) = 0.7 NWB + 0.3 GT. The permissible heat exposure threshold limit value in this type of occupation is 26.7°C.

RESULTS

The data of the studied groups are presented in Table 1. Nonsignificant differences were found between the two groups regarding mean body temperature, mean scrotal temperature during work, and difference between body temperature and scrotal temperature. Also, nonsignificant differences were demonstrated between the two groups regarding semen parameters being in the normozoospermic range.

DISCUSSION

The concept that an elevation of testicular temperature results in impairment of spermatogenesis is widely accepted. As depicted in the present study, heat stress imposed on the exposed group was found to be 38.9°C WEGT, which is above the permissible heat exposure threshold limit of 26.7°C WBGT in such work. Although the heat stress to which workers were exposed was above the permitted standard levels, the workers were found to be acclimatized, as verified by normal body temperature, pulse, and excessive sweating during the shift. Wiegman (19) indicated that good acclimatization level occurs according to the fact that on the first exposure to hot environment, elevation of skin and body temperature occurs, and when heat acclimatization develops, both skin and body temperature decreases. Acclimatization to heat consists mainly of additional capacity for cutaneous vasodilatation and the capacity of earlier onset and maintenance of sweating. Mutchler (20) showed that exposure for 1–4 hours for 5–7 days is usually sufficient for the development of good heat acclimatization, in addition to other racial and environmental factors.

Nonsignificant differences were found regarding the body and scrotal temperatures between the exposed group and the control subjects; the mean differences between the temperatures were 2.58°C and 2.69°C, respectively, which were considered to be normal (21). Namiki et al. (22, 23) indicated that high temperature may not disturb the Leydig and Sertoli cell

functions in the short term. Candas et al. (24) indicated that the temperature response of the scrotal area exhibited the largest inertia, and this observation is likely the consequence of heat exchange via the vascularization of testes and scrotum, which is more efficient than in other parts of the body in limiting local heat storage, thus alleviating heat stress of the testis. The pulsatile nature and the synchronous pattern of the scrotal evaporative heat loss indicated that scrotal sweating takes place, although the gradient response appeared to be less marked than elsewhere in the body. Bingöl-Koloğlu et al. (25) showed that contrary to other striated muscles, elevated temperature increases the contractility of cremastric muscle, which reflects the attempts at regulating testicular blood flow or temperature.

Skandhan and Rajahariprasad (26) demonstrated that during spermatogenesis a large amount of heat is liberated as a by-product of energy utilization that is carefully liberated by scrotum. The thin skin with no subcutaneous fat, scanty hair distribution, and presence of more sweat glands on it permits easy escape of heat. Sealfon and Zorgniotti (27) indicated that in humans, any internal or external factor causing a temperature change would not trigger or activate a feedback mechanism to control the resulting testis temperature. A major factor in subfertile semen may be the inability to check excessive temperature of the testis, which impairs its ability to produce mature spermatozoa. Gracia et al. (28) conducted a large retrospective case-control study, with nonsignificant associations noted between male fertility status and exposure to shift work, metal fumes, electromagnetic fields, solvents, lead, paint, pesticides, work-related stress, or vibration.

However, Thonneau et al. (29) concluded that male heat exposure must be considered to be a risk factor for male infertility. In men under normal healthy environmental conditions, the testicular thermoregulation system is able to maintain "normal" scrotal hypothermia. In men repeatedly subjected to abnormal situations and in men with impaired arteriovenous testicular systems, there may be chronic thermodysregulation which may, in time, result in substantial changes in sperm characteristics, as has been reported in animal models.

In the present study, fertile workers exposed to elevated environmental temperature had normozoospermic semen parameters, provided that no functional or anatomic disorders of the gonads were present, owing to body acclimatization. However, sperm count may be affected under such environmental conditions, especially on borderline cases.

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