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Effect of different types of textile fabric on spermatogenesis: an experimental study

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Summary. The effect of different types of textile fabric on spermatogenesis was studied. Twenty-four dogs were divided into two equal groups, one of which wore cotton underpants and the other polyester ones. Seven dogs wearing nothing were used as controls. The underwear was fashioned to fit loosely in the scrotal area so as to avoid its insulating effect. It was worn continuously for 24 months during which the semen character, testicular temperature, hormones (serum testosterone, follicle stimulating hormone, luteinizing hormone, prolactin) and testicular biopsy were examined. The garment was then removed, and the same investigations repeated through another 12 months. The results were analysed statistically. In the polyester group the testicular temperature showed insignificant changes during the period when the pants were worn ($P > 0.05$). By the end of the 24 months there was a significant decrease in sperm count and motile sperms, with an increase in abnormal forms ($P < 0.001$); the testicular biopsy showed degenerative changes. After garment removal the semen character improved gradually to normal in 10 dogs; two remained oligozoospermic. There were insignificant changes ($P > 0.05$) in hormones during the study. In contrast, the cotton and control groups showed insignificant changes ($P > 0.05$) in all the aforementioned parameters during the 36 months of the study. The polyester pants thus had a deleterious effect on spermatogenesis in the dogs which was, however, reversible in the majority of cases. The cause of this effect is unknown, but it may be assumed that the electrostatic potentials generated by the polyester fabric play a role in it.

Key words: Fertility – Infertility – Spermatogenesis – Sterility – Testicle

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Idiopathic male infertility is a challenging problem for the medical profession. Even the immense scope of the available investigations is unable to provide an etiological diagnosis for all infertile patients.

In addition to the endocrine [2, 10, 11] and pathological conditions [14, 16, 17, 20] of the contents which may cause infertility, environmental conditions such as disordered testicular thermoregulation [6, 7, 15] could also affect the spermatogenic function of the testicle. The literature contains a vast number of reports on the effect of heat on testicular function, but no mention could be found of the influence of textiles on spermatogenesis. This stimulated the author to study the effect on the spermatogenic function of the canine testicle of the two fabrics preferred in the manufacture of men's underwear: cotton and polyester. This paper presents the results of the study.

Materials and methods

The study comprised 31 male mongrel dogs, varying in weight from 10 to 18 kg [mean 14.2 + 2.6 (SD) kg]. The testicles and spermatic cords of the animals were examined to ensure absence of masses or testicular atrophy. At least two semen specimens, 2 weeks apart, and a testicular biopsy were examined. A partial erection of the dog's penis was achieved by digital massage, and an artificial vagina applied for collection of semen. The rectal and right and left intratesticular temperatures were measured using a needle probe thermometer. Animals with abnormal semen quality and/or testicular biopsy were excluded from the study.

Twenty-four of the 31 dogs were then divided into two groups of 12 dogs each. Underpants were prepared from 100% cotton material for the first group (cotton group) and from 100% polyester (polyethylene terphthalate) for the second group (polyester group); 7 control dogs were left without pants. The cotton or polyester garments were fashioned to cover the distal third of the dog's back including scrotum, perineum and the upper parts of the hind limbs. Openings were made for the anal orifice, penis and tail.

Care was taken to avoid the effect of scrotal insulation and temperature elevation, as well as to allow for free scrotal reaction to temperature variations. The garment was therefore styled to be 2–3 cm away from the scrotum. The dogs were made to wear the

Table 1. Sperm count (10^6/ml) before and 24 months after wearing the polyester underpants and 12 months after their removal

	Before wearing pants			After 24 months of wearing pants			12 months after removal of pants		
Sperm count:	21–40	41–60	>60	21–40	41–60	>60	21–40	41–60	>60
Dogs (*n*)	0	5	7	12	0	0	2	6	4
Dogs (%)	0	41.7	58.3	100	0	0	16.7	50	33.3

Table 2. Sperm motility before and 24 months after wearing the polyester underpants and 12 months after their removal

	Before wearing pants			After 24 months of wearing pants			12 months after removal of pants		
Motile sperm:	30–50%	51–70%	>70%	30–50%	51–70%	>70%	30–50%	51–70%	>70%
Dogs (*n*)	0	0	12	12	0	0	1	1	10
Dogs (%)	0	0	100	100	0	0	8.35	8.35	83.3

pants day and night for 24 months; only when soiled were the garments immediately replaced by fresh ones.

During the 24 months the dogs wore the pants the testicles were examined twice monthly for consistency and size using a Schirren orchidometer. The intratesticular and rectal temperatures as well as semen specimens were examined monthly. Testicular biopsy was examined histologically at the 12th and 24th months from the start of the experiment.

Hormonal assay

Blood samples for hormonal assay were taken every 6 months during the 2 years of the study. Sampling was always done at about the same time of day. Serum testosterone, follicle stimulating hormone (FSH), luteinizing hormone (LH) and prolactin were measured by radioimmunoassay using Diagnostic Products Corporation kits. The serum level of testosterone was measured according to the method of Smith and Rodriquez-Rigua [19], FSH and LH according to Santner et al. [13] and prolactin according to Cowden [3].

Removal of pants

After 24 months the cotton or polyester pants were taken off the dogs. The investigations were continued in the manner described above for another 12 months. A testicular biopsy was taken from those dogs in which the semen had not returned to normal.

Statistical analysis

The results were analysed statistically using Student's *t*-test.

Results

Polyester group

Clinical examination of the two testicles during the 24 months of wearing the polyester pants showed no significant changes in consistency or size ($P > 0.05$).

The testicular temperature before wearing the pants varied from 34.1 to 34.7°C with a mean of 34.3°C for both testicles. The rectal temperature varied from 37.6 to 38.2°C with a mean of 37.9°C. During the whole period of wearing the polyester garment the testicular temperature was not significantly different from that before the garment was worn ($P > 0.05$).

The semen prior to the test showed normal findings in all the dogs (Table 1). During the 24 months of the test no significant changes ($P > 0.05$) were seen up to the 12th month of the test, when 8 of the 12 dogs showed a significant drop in sperm count ($P < 0.001$) which varied from 30 to 42×10^6/ml with mean of 34.6 ± 3.2 (SD) $\times 10^6$/ml. The motile sperms varied from 46% to 58% (mean 49.6 ± 6.8%) and abnormal forms from 43% to 68% (mean 52 ± 12.2%). In the remaining 4 dogs, significant changes in semen character ($P < 0.001$) appeared only in the 16th month, when a diminished sperm count (mean $30.2 \pm 4.6 \times 10^6$/ml), diminished motile sperms (mean 43.6 ± 10.3%) and increased abnormal forms (66.4 ± 8.2%) were found.

By the end of the 24th month all the dogs in this group had significant changes in semen character ($P < 0.001$). The mean sperm count was $32.2 \pm 4.6 \times 10^6$/ml, motile sperms 46.2 ± 5.9 and abnormal forms 58.6 ± 10.8% (Tables 1–3).

The testicular biopsy at the 12th month revealed in 7 dogs minor degenerative changes in the seminiferous tubules in the form of slight exfoliation of the germ cells. Five dogs showed no changes. By the end of the 24th month of wearing the polyester pants the degenerative changes had become manifest in all the dogs. The Sertoli cells showed cytoplasmic vacuolation. The spermatogonia also revealed vacuolation and disarray in the junctional system with the Sertoli cells. The Sertoli and germ cells were displaced and pushed toward the lumen of the seminiferous tubules. The interstitial tissue and Leydig cells were normal.

Table 3. Sperm morphology before and 24 months after wearing the polyester underpants and 12 months after their removal

	Before wearing pants		After 24 months of wearing pants		12 months after removal of pants	
Abnormal sperm:	<40%	>40%	<40%	>40%	<40%	>40%
Dogs (*n*)	12	0	0	12	10	2
Dogs (%)	100	0	0	100	83.3	16.7

Table 4. Mean serum levels of testosterone, FSH, LH and prolactin before and 24 months after wearing the polyester underpants and 12 months after their removal[a]

	Testosterone (ng/ml)	FSH (mIU/ml)	prolactin (ng/ml)	LH (mIU/ml)
Before wearing pants	2.29 ± 0.46	4.32 ± 1.2	4.6 ± 0.6	3.1 ± 0.6
After 24 months of wearing pants	2.32 ± 0.50	4.52 ± 1.6	4.2 ± 0.8	3.4 ± 0.8
12 months after removal of pants	2.23 ± 0.38	4.38 ± 1.1	4.4 ± 0.9	3.3 ± 0.5

FSH, Follicle stimulating hormone; *LH*, luteinizing hormone
[a] Values are given as the ± SD

After removal of the pants the character of the semen showed gradual improvement starting between the third and the six months. The pre-experimental normal levels were achieved by the seventh month in 4 dogs and by the 11th month in a further 6 dogs (Tables 1-3). In 2 dogs character of the semen had not reached the normal level by the 12th month; the count was 21.6×10^6/ml in 1 dog with 52% motile sperms and 62% abnormal forms, and in the other 23.8×10^6/ml with 48% motile sperms and 86% abnormal sperms. The testicular biopsy taken from the 2 dogs at the end of the 12th month showed persistence of the tubular degenerative changes that had occurred during the period they were wearing the polyester pants.

Hormonal assay

The serum levels of testosterone, LH, FSH and prolactin during or after the test did not show significant changes compared with pre-experimental values ($P > 0.05$) (Table 4).

Cotton group

There were no significant changes ($P > 0.05$) in testicular size or consistency, testicular and rectal temperatures, semen character, hormone levels or testicular biopsy of the dogs during the 24 months of wearing the cotton pants or in the 12 months thereafter.

Control group

The control group also showed insignificant changes ($P > 0.05$) in the abovementioned parameters during the period of study.

Discussion

The present study demonstrates that, in contrast to cotton garments, polyester pants had a deleterious effect on spermatogenesis in all dogs of the test group. This is evident from the defective character of the semen collected while the animals were wearing the polyester pants, as well as from the testicular biopsies.

The effect occurred after a variable period which ranged from 12 to 16 months of wearing the pants. By the end of the 24th month all the dogs were oligospermic. The testicular biopsy showed insignificant changes by the 12th month, while the degenerative changes in the seminiferous tubules were manifest in all the dogs on the biopsy at the 24th month. The serum levels of testosterone, FSH, LH and prolactin showed insignificant changes during the period of study.

After the polyester pants had been removed, semen character improved within 12 months in all but 2 of the dogs. The latter showed persistent oligozoospermia and testicular degenerative changes on biopsy.

The dogs of the cotton and control groups showed no significant semen, testicular or serum hormone changes during the period of this study.

These results point to the injurious effect of polyester garments on the spermatogenic function of the testicle. This spermatogenic depression was reversible in 10 cases and persisted in 2 when the polyester pants had been removed. It seems that in these 2 animals, irreversible testicular damage had occurred, as the testicular biopsy 12 months after removal of the pants showed persistence of degeneration of the seminiferous tubules.

The cause of the spermatogenic depression as induced by wearing the polyester pants is unknown. It may be argued that it could be due to the disordered thermoregulatory function of the scrotum resulting from scrotal insulation by the polyester pants. To avoid this possibility, the pants were styled from the start of the experiment to be loosely applied to the scrotum. In addition, the testicular–rectal temperature differences were not significantly different from those prior to the experiment.

Effect of fabric-generated electrostatic potentials on spermatogenesis

Non-ionizing radiation (e.g. microwave, ultraviolet and laser) has a harmful effect on the living organism [8]. Many investigators have reported microwave-induced testicular damage [1, 12]. Similarly, ultrasound waves induce a significant reduction in spermatogenesis [4, 5, 9].

As regards the synthetic polyester fabric, our preliminary studies [18] have shown that it generates electrostatic potentials, while we could not detect such potentials in cotton fabrics. It may be that these potentials act on the testicular germ cells leading to diminished spermatogenesis; the mechanism needs to be investigated.

The accumulated electrostatic charges on the scrotal skin are due to the friction of the polyester underpants with the skin [18]. As a result of friction, equal and opposite charges are accumulated on the skin surface and on the inner surface of the pants next to the skin. Negative charges are created on the inner surface of the pants and positive ones on the scrotal skin [18]. The latter produce induced charges with negative signs on the other surface of the scrotal sac. It has been suggested that these equal but opposite charges created on the two aspects of the scrotal sac produce an "electrostatic field" extending from one aspect of the scrotum to the other, traversing the scrotal contents [18]. This field would disturb the testicles and/or epididymis leading to impaired spermatogenesis.

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