Increase in scrotal temperature in car drivers

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Several recent studies have reported a gradual decline in sperm production in men. Endocrine disrupters as well as lifestyle have been suggested as risk factors. One lifestyle factor that may affect human fertility is driving a vehicle for a prolonged period. Several authors have suggested that driving position may increase the scrotal temperature. In order to validate this hypothesis we conducted continuous monitoring of scrotal temperature in real conditions, i.e. in men driving a car for a prolonged period. Nine volunteer men were asked to walk outside for 40 min and then to drive a car for 160 min. Scrotal temperatures were measured from thermocouples and values recorded every 2 min on a portable data recorder. Scrotal temperature increased significantly (P < 0.0001) in driving posture after 2 h of driving, reaching a value 1.7–2.2°C higher than that recorded while walking. This link between driving position and increased scrotal temperature indicates a potential exposure of male reproductive function to lifestyle factors. Key words: driving posture/lifestyle factor/male fertility/occupational exposure/scrotal temperature

Introduction

Several recent studies have reported a gradual decline in sperm production in men in various regions of the world whereas others have not found such a decline (Lerchl and Nieschlag, 1996; Swan et al., 1992) reported no effect of sedentary activities on sperm motility (Chia et al., 1994) or to have lower sperm count (Henderson et al., 1986) than other occupational groups.

A study conducted in Italy in taxi drivers and control subjects (of similar age and smoking habits) (Figa-Talamanca et al., 1996) showed that the percentage of spermatozoa with normal morphology was significantly lower in taxi drivers than in the controls. This result was more pronounced in those who had been working as drivers for a long time. In a study carried out in Hungary in men consulting for infertility (Sas and Szőlősi, 1979), it was observed that a higher proportion of them were professional drivers than were members of the general population coming from the same catchment area. They also found that the most severe sperm anomalies were associated with the total number of years of driving. In other studies, workers coming from ‘transport and communication' industries were reported to be at higher risk of abnormal sperm motility (Chia et al., 1994) to or have lower sperm count (Henderson et al., 1986) than other occupational groups.

Contradictory results have been reported (Buiatti et al., 1984). By comparing oligozoospermic and azoospermic males with control patients (sperm count >20 × 10⁶/ml) attending the same clinic, the sitting position was not found to be related to oligozoosperma or azoospermia. Similarly, another study (Oldereid et al., 1992) reported no effect of sedentary activities (assessed from a questionnaire) on semen quality in 252 infertile patients.

In most of the studies quoted above, an increase in scrotal temperature (‘heat effect') was the most frequently suggested factor to explain the relationship between driving/sitting position and alterations of sperm characteristics or infertility. However, this hypothesis has never been validated by any scrotal temperature measurements in any of those studies.

Very few experimental studies have evaluated the consequences of various postures, supine, sitting and standing, on scrotal temperature. The main conclusions are that scrotal temperature is lower when walking as compared to the sitting position (Rock and Robinson, 1965; Brindley, 1982; Jockenhövel et al., 1990). However the significance of these results is limited first by the small number of patients involved in each study (only one individual in the study performed in 1982) and also by the restricted evaluation of scrotal temperature measurement, with no dynamic recording except for one study (Jockenhövel et al., 1990).

In order to validate and to measure the effect of the driving position on scrotal temperature, we conducted a continuous monitoring of the scrotal temperature in men driving a car for a continuous period of 160 min.

Materials and methods

Nine healthy men gave informed consent for voluntary participation in the study. They all underwent a medical and andrological examina-
tion in our andrological centre. Two cutaneous thermocouples (K type; Bioblock Scientific Inc., Illkirch, France) were then attached to the skin on the anterior face of the scrotum, one corresponding to the right and the other to the left testis. The thermocouples were fixed to the skin using thin transparent tape, and they were connected to a small portable data recorder attached to the belt (Bioblock Scientific Inc.). The functioning of the sensors was checked up and temperatures were then automatically recorded at 2 min intervals.

For the present study, the men were recommended to wear their usual clothes. They were asked to walk outside for 40 min along the same pre-determined route and then to drive a car (Sud Motors Cie, Ramonville Saint Agne, France) for 160 min without using the air conditioning.

Ambient temperature during walking and driving periods was also recorded by means of a third probe connected to the portable data recorder. After 200 min of experimentation the thermoprobes were disconnected, and the measurements collected in the data recorder were downloaded to a computer through a specific program.

**Statistical analysis.**

Data were analysed using analysis of variance (ANOVA). Mean temperature was calculated for the periods (walking and after 2 h of driving) in which the values were homogeneous, i.e. when the scrotal temperatures were stable.

**Results**

As shown in Figure 1, scrotal temperatures increased while driving a car. This change in mean scrotal temperature could be split up into three periods: (i) during the first 20 min of driving, there was a rapid increase from 34.2°C to 35.5°C; (ii) from 20 min to 120 min of driving, the increase was less rapid, from 35.5°C to 36.2°C; (iii) after 2 h of driving, the mean temperature stabilized at around 36.2°C.

During the three driving periods, mean ambient temperatures were respectively 25.3 ± 0.4°C, 26.5 ± 0.3°C, 27.5 ± 0.2°C, and the ambient temperature was 24.7 ± 0.2°C during the walking period.

When comparing the values recorded during the walking period (W) to those recorded after 2 h of driving (D), the mean (±SD) scrotal temperature increased from 34.5 ± 1.1 °C (W) to 36.2 ± 0.8°C (D) on the left side and from 34.2 ± 0.8°C (W) to 36.4 ± 0.5°C (D) on the right side (P < 0.0001; ANOVA for repeated measures).

Thus, after 2 h of driving, the mean scrotal temperature was increased by 1.7°C on the left side and 2.2°C on the right side when compared to the corresponding mean scrotal temperatures during the walking period.

**Discussion**

This study demonstrates that driving is associated with an increase in scrotal temperature. Such an increase reaches a value of 1.7–2.2°C when driving continuously for more than 2 h. It is well known that scrotal temperature is related to the ambient temperature. In the present study, the mean increase in ambient temperature when driving, which was around 3°C, cannot be responsible for the observed increase in scrotal temperature since a 1°C increase in ambient temperature induces a 0.1°C increase in scrotal temperature (Brindley, 1982).

Increases in scrotal temperature with particular physical activities and postures, including the sitting position, have been reported in previous studies (Rock and Robinson, 1965; Brindley, 1982). However, our results are the first to have been obtained for men driving a car in what could be considered as ‘normal’ conditions.

The successful use of a portable data recorder for continuous determination of scrotal temperature has already been reported (Jockenhövel et al., 1990). As stated in that report, we agree that thermographic recordings or infrared thermometry must be replaced by use of such thermocouples. The use of a mercury thermometer does not allow continuous measurements.

In most mammals the main function of the scrotum is to adjust to heat stress to prevent heat arriving at the testis (Waites, 1991). This adjustment has been found to be partially due to the capacity of the scrotal skin to extend its surface area and to evaporate the sweat secreted by the scrotum in rams (Waites and Voglmayr, 1963). In humans, extension of the surface area is obvious and an increased fluid excretion has been reported (Candas et al., 1993).

The increase observed in scrotal temperature during driving in the present study can be explained by the situation of the scrotum while driving. In such a posture, the spreading of legs apart is of limited extent so that the scrotum is trapped between the thighs. Such a scrotal situation has two consequences. Firstly, it prevents the relaxation of the scrotal skin which is one of the possible routes of heat loss through the increase in the surface area of the skin (Fowler, 1969). Secondly, whereas the scrotum is surrounded by ambient air while walking, it rests on the thighs in which the temperature is close to body temperature while driving.

The question arises as to what the consequences of an increase in scrotal temperature on sperm characteristics and/or fertility might be. Normal human testicular temperature is physiologically maintained within a range of 32–35°C (Mieusset and Bujan, 1995). As in most mammals, such a normal testis temperature is a necessary condition for quantitatively and qualitatively normal spermatogenesis (Setchell and Mieusset, 1996). In human experimental studies in which a 1–2°C increase in testis temperature was induced at least during waking hours and repeated
daily, spermatogenesis was impaired: sperm count and percentages of motile and of normal form spermatozoa were depressed (Mieusset et al., 1985, 1987; Shafik, 1992). This depression was strong enough to be associated with infertility (Shafik, 1992; Mieusset and Bujan, 1994). All these modifications were reversible within 1 year after the artificial increase in testis temperature was removed.

The change that we measured in men who were driving was an increase in temperature of the scrotum, and not an increase in temperature of the testis. However, several authors have reported that scrotal and testicular temperature are strongly correlated (Zorgniotti and MacLeod, 1973; Zorgniotti, 1982; Kurz and Goldstein, 1986; Coltet et al., 1988). Thus, as scrotal temperature is increased, testis temperature must be correspondingly increased after 2 h of driving.

Could an increase in scrotal temperature have any effects on spermatogenesis? When an increase in scrotal temperature was induced in volunteer men, results have been conflicting. Indeed, a mean increase of about 1°C in scrotal temperature during waking hours resulted in depressed sperm count, motility and morphology in one study (Rock and Robinson, 1965), but in no effects on sperm characteristics in another experiment (Wang et al., 1997). However, in these two studies, the scrotum was submitted to a lower heat stress (1°C increase) than the one observed in the present study (1.7–2.2°C increase). Thus an effect on sperm characteristics of such an increase in scrotal temperature in men driving cars can be strongly suspected.

Moreover, an increase in scrotal temperature may result in impaired fertility without any anomalies detected in usual semen analyses. Indeed, a 2°C daily induced increase in scrotal temperature of conscious rams during 16 h per day for 4 days resulted in no modifications in sperm count and motility but in a 50% increased miscarriage rate in ewes inseminated with such semen as compared to ewes inseminated with a similar number of motile spermatozoa from normal control rams (Mieusset et al., 1992; Setchell, 1994).

From the experimental data reported in the previously quoted studies, the increase in scrotal temperature observed in the present study in men driving cars could be one of the strongest pieces of evidence to explain the longer time required to achieve conception in men who are occupational car drivers (Figa-Talamanca et al., 1996; Thonneau et al., 1996). To conclude, our study demonstrates that car driving is associated with an increase in scrotal temperature. While scientific background strongly suggests an effect of such an increase in scrotal temperature upon spermatogenesis, further studies are required to confirm this possibility. However, our results showing a link between driving and increase in scrotal temperature indicate a potential exposure of male reproductive function to lifestyle factors.

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References

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