

Thermal asymmetry of the human scrotum

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BACKGROUND: Scrotal temperatures in men have been reported to be either similar on both sides or higher on the left than the right scrotum. We aimed to clarify this discrepancy from new data. **METHODS:** Retrospective analyses of scrotal temperatures in men aged 20–52 years measured every 2 min with probes connected to a data collector in three experiments. In Experiment I, eight men have been submitted to four successive body positions for 15 min each, first naked then clothed. Experiment II involved 11 postal employees working in a standing position for 90 min continuously. Experiment III involved 11 bus drivers and a 90 min period of continuous driving. Outcome parameters were left and right scrotal temperatures. **RESULTS:** In Experiment I, mean values and kinetics of scrotal temperature differed significantly in the naked and clothed state. In all three experiments, left scrotal temperature in the clothed state was higher than right scrotal temperature in terms of mean values and temperature kinetics. **CONCLUSIONS:** Lack of thermal symmetry was seen in the right and left scrotum, whether naked or clothed, and this applied regardless of position or activity when clothed. This thermal difference between right and left scrotum could contribute to the asymmetry in the male external genital organs.

Keywords: clothing; genital asymmetry; kinetics; posture; scrotal temperatures

Introduction

Scrotal temperature, assessed by a single measurement in fecund or fertile men, has been reported to be identical on both right and left when measured with a Hg thermometer (Zorgniotti and McLeod, 1973; Zorgniotti and Sealfon, 1988; Ali *et al.*, 1989; Mieusset *et al.*, 1995), but higher on the left than on the right when measured with infrared thermometry (Zorgniotti *et al.*, 1979) or cutaneous thermocouples (Zorgniotti *et al.*, 1982).

Measurement of scrotal temperature using a continuous recording system was first performed in 1990 (Jockenhövel *et al.*, 1990) and has since been applied in several studies. Lerch *et al.* (1993) found no difference in mean scrotal temperature between right and left scrotum in six normal fertile men whether measured by day or night. In contrast, Jung *et al.* (2001) reported a median value for scrotal temperature measured over 24 h in 10 fecund men of 34.99°C on the right and 35.29°C on the left side. In a recent study, the same authors found that mean scrotal temperature was significantly higher on the left (35.56°C) than on the right (35.37°C) in 50 male volunteers (without a history of infertility and with a normal clinical examination) when clothed (Jung *et al.*, 2005).

Thus, the issue of a potential difference in temperature between right and left scrotum in fecund or fertile men was raised. It brought into question whether measurements performed on one side of the scrotum only (Jockenhövel *et al.*,

1990), or even at the level of the septum (Munkelwitz and Gilbert, 1998; Hjollund *et al.*, 2002) are valid, as these measurements are based on a functional equivalence of right and left hemi-scrotum.

In this article, we report on a series of findings relevant to this question that were obtained in the course of three studies performed with the primary aim of evaluating the effect of body position and clothing on scrotal temperature in fertile and fecund men.

Materials and Methods

After the proposed experimental studies had been approved by the local Ethics Committee, all volunteers gave written informed consent for participation in the studies.

In all the three experiments, temperatures were measured every 2 min with the model AM-7001 precision skin thermometer (accuracy 0.1% of reading, precision 0.03°C and sensor type K; Anritsu Meter Co., Tokyo, Japan). Probes were connected to a data collector slipped into a leather case that is either hung on the trouser belt or slung from a shoulder strap. Using transparent tape (Jockenhövel *et al.*, 1990), probes were attached to the skin at the anterior aspect of each hemi-scrotum (scrotal temperatures). Data were then transferred to statistical programmes on a personal computer.

From anamnesis and clinical examination, all men were free of any medical, surgical or occupational histories, with no grade 1–3 varicocele (clinical evaluation) and no testicular hypo- or atrophy found.

Testicular volumes were evaluated with callipers in Experiment I and with a Prader orchimeter in Experiments II and III.

Experiment I

Eight fertile (having fathered at least one child) male volunteers have been included. Their mean age was 36.6 years (range 20–48). Four successive body positions were maintained in the same room: supine, standing, seated with legs apart (at an angle $\sim 70^\circ$) and seated with legs crossed (when legs crossed, the position of left over right or vice versa was not recorded). Each position was held for 15 min. All probes were placed with the men naked and standing. After 3–5 min acclimation in the supine position, recording was started for the four positions in the naked state. Recording was then stopped and the men stood up and dressed within 5 min with normal clothing: long sleeve shirt, boxer shorts and trousers, all of cotton composition and light-weight grade. After lying down, recording was started again for the four positions in the clothed state. Ambient room temperature was $25.6 \pm 2.0^\circ\text{C}$.

Experiment II

Eleven employees at a postal sorting office were selected for inclusion in this study because their working pattern consisted of 90 consecutive minutes in a standing position, preceded by about 10 min walking. Their work was to sort mail (maximum weight = 5 kg) into pigeon-holes, which principally involved short periods of movement inside a large room.

Their mean age was 36.7 years (range 26–45); seven men were fertile (having fathered at least one child) and four were fecund (without any history of reproductive pathology and no desire for children)

A medical history was taken, a clinical examination performed and probes and data collector put into position in the hour preceding the start of work. Data were recovered at the end of the work period. Ambient room temperature was $25.0 \pm 1.9^\circ\text{C}$.

Experiment III

This experiment included 11 bus drivers selected because their working pattern consisted of driving continuously for 90 min (sitting), preceded by walking for 10–15 min.

Their mean age was 37.8 years (range 28–52); eight men were fertile (having fathered at least one child) and three were fecund (without any history of reproductive pathology and no desire for children). Ambient bus temperature was $25.2 \pm 2.2^\circ\text{C}$.

A medical history was taken, clinical examination performed and probes and data collector put into position in the hour preceding the start of work. Data were recovered at the end of the work period.

Statistical analyses

For statistical analysis, Kolmogorov–Smirnov test was used to detect normal distribution. The mean value for each measurement (all positions considered together in the naked, then clothed state, in Experiment I) was calculated first. A mean and SD were then calculated on the basis of this value for all men in each of the three experiments. The Wilcoxon test and Student's paired *t*-test were used to compare means. In each of the three experiments, the existence of a significant thermal difference between the two scrotums was assessed by nullity testing the mean of the difference between the curves representing changes over time in right and left scrotal temperature, point by point, in the naked and clothed state. A value of $P < 0.05$ was used to indicate statistical significance.

In Experiment I alone, the range of scrotal temperature (T_s) was defined as the difference between $T_{s\text{max}}$ and $T_{s\text{min}}$. This difference

was calculated in each man for each scrotum, in the naked and clothed state. On this basis, the mean for all men was calculated for each scrotum in each state. To assess changes in the range of T_s from the naked to clothed state, we calculated the following ratio of variation:

$$\begin{aligned} \text{Individual ratio of variation} &= \frac{\text{range when clothed}}{\text{range when naked}} \\ &= \frac{(T_{s\text{max}} - T_{s\text{min}})_{\text{clothed}}}{(T_{s\text{max}} - T_{s\text{min}})_{\text{naked}}} \end{aligned}$$

This ratio was calculated for each man, for each scrotal sac. On the basis of this value, the mean ratio for all men was calculated for each scrotum and expressed as a percentage, which made it possible to assess the change in range of T_s in the clothed, compared with naked state, using the formula: percentage change = 100% minus value of ratio of variation.

Results

Experiment I

A significant difference in temperature could be observed between the right and left scrotum in the clothed state, with a mean (\pm SD) for the right scrotum ($34.38 \pm 0.37^\circ\text{C}$) that was lower ($P < 0.001$) than the left ($34.56 \pm 0.25^\circ\text{C}$). This difference was equally significant in the naked state, but the value for the right scrotum ($33.24 \pm 0.67^\circ\text{C}$) was higher ($P < 0.001$) than that of the left ($32.99 \pm 0.78^\circ\text{C}$).

Furthermore, a change could be seen in the relative position of the temperature curves for the right and left scrotum in the naked (Fig. 1A) and clothed state (Fig. 1B). The curve for the left scrotum was below that of the right scrotum when naked, although the opposite applies when clothed. The mean of the difference between the curves for the two scrotums (point by point) was significant, when naked and when clothed (Table 1). Thus, it was not only the mean value but also the kinetics of scrotal temperature that differed significantly between right and left scrotum, regardless of whether in the naked or clothed state.

A significant difference between the naked and clothed state was also found for the mean ranges of temperature for each scrotum: on the right, $2.75 \pm 0.6^\circ\text{C}$ when naked versus $1.96 \pm 0.39^\circ\text{C}$ when clothed ($P = 0.015$); on the left, $3.47 \pm 0.92^\circ\text{C}$ when naked versus $1.55 \pm 0.40^\circ\text{C}$ when clothed ($P = 0.007$). Furthermore, the ratio of variation in scrotal temperature differed significantly between the right and left scrotum (Table 1) that indicated a significantly more marked reduction in range of T_s on the left ($100 - 46.4 = 53.6\%$) than on the right ($100 - 71.6 = 28.4\%$) side, when going from the naked to clothed state.

Experiments II and III

Left scrotal temperature was higher than right scrotal temperature in postmen (Fig. 2) and in bus drivers (Fig. 3). A significant difference between mean temperatures of left and right scrotum was seen for postmen: $33.41 \pm 0.26^\circ\text{C}$ on the right versus $33.82 \pm 0.18^\circ\text{C}$ on the left ($P < 0.001$). In the case of bus drivers, this difference was also significant: $35.34 \pm 0.25^\circ\text{C}$ on the right versus $35.92 \pm 0.19^\circ\text{C}$ on the left ($P < 0.001$).

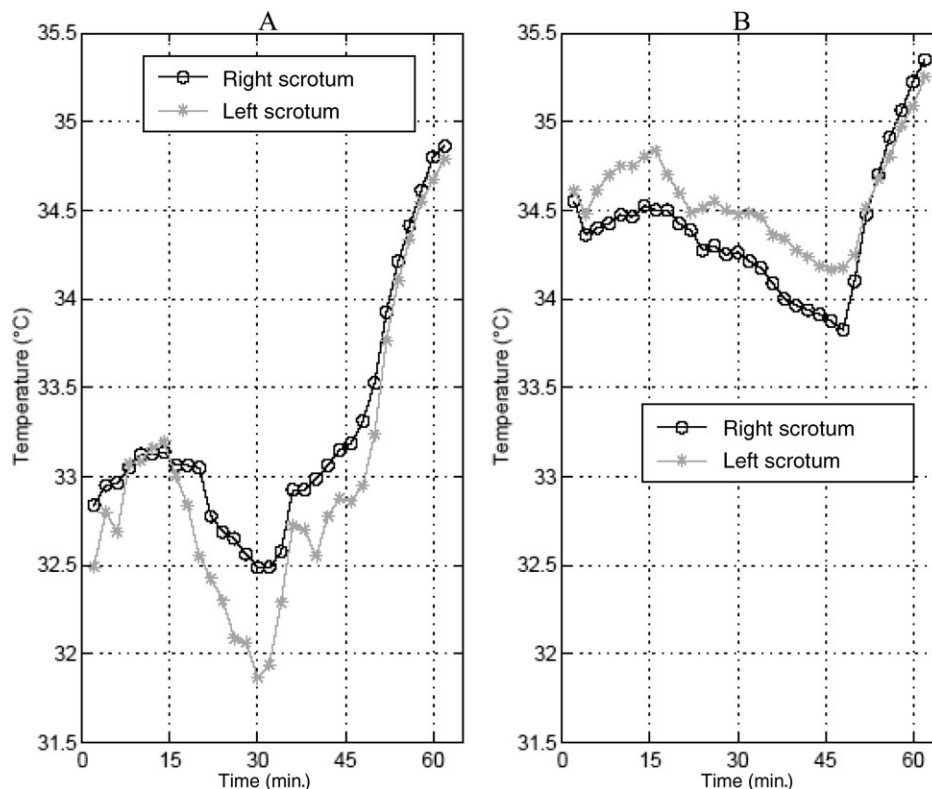


Figure 1: Changes over time in right and left scrotal temperature in (A) naked and (B) clothed volunteers ($n = 8$; Experiment I). Each point represents the mean of measurements at each time point in the eight men. Successive 15-min periods correspond to the following positions, respectively: supine, standing, seated with legs apart and seated with legs crossed

The mean of the difference between the curves for both scrotums (point by point) was significant (Table 2), which means that not only the mean values but also the kinetics of scrotal temperature differed significantly between right and left scrotum in postmen and bus drivers.

Discussion

In the present study, we found for each experiment a mean scrotal temperature in the clothed state, which was significantly higher on the left than on the right, thus confirming the findings reported by Jung *et al.* (2005). However, since in the naked state mean scrotal temperature (Experiment I) was significantly lower on the left than on the right, the clothed state caused a greater increase in left scrotal temperature than right scrotal temperature. This difference in thermal behaviour of the left and right scrotums was thus also expressed by a mean ratio of variation in scrotal temperature which was significantly more reduced on the left (54%) than on the right (28%) in the clothed compared with the naked state.

In Experiments II and III, two opposite body positions were used: a seated position (driving) and standing position (walking). In fact previously, on the one hand, the seated position, when driving, was associated with a 2°C increase in scrotal temperature after driving for 2 h (Bujan *et al.*, 2000). On the other, it was in the standing position that scrotal temperature was lowest, compared with the seated or supine position (Rock and Robinson, 1965; Zorogniotti and McLeod, 1973; Brindley, 1982; Jockenhövel *et al.*, 1990). Thus in Experiments

II and III, where two opposite positions in terms of possible scrotal temperature were used, left and right scrotal temperatures were significantly different both in terms of mean value and kinetics.

The range of activities brought together in the present study, which involved successive positions without physical activity (Experiment I, volunteers), short periods of walking with moderate physical activity (Experiment II, postmen) and the position assumed when driving (Experiment III, bus conductors), indicated that the thermal behaviour of the left scrotum differed from that of the right, in a way that was not associated with type of activity. This difference in thermal behaviour was also present when subjects changed from the naked to clothed state.

Since all men in the present study were not wearing identical clothing (except for clothed/Experiment I), one can argue that this could induce a bias in the results. However, although Brindley (1982) and Jung *et al.* (2005) suggested that subjects wearing loose fitting boxer shorts have lower scrotal temperature than those wearing tight fitting Y-fronts, other authors argued that no actual difference was evident between men wearing boxers and those wearing briefs, whatever the size and tightness (Zorogniotti *et al.*, 1982; Munkelwitz and Gilbert, 1998; Hjollund *et al.*, 2002). Moreover, while Jung *et al.* (2005) observed a significantly higher left than right scrotal temperature, this was not associated with the presence or type of underwear.

As the main function of the scrotum is to allow heat in the underlying testicle to be transferred to the external environment in such a way as to ensure thermal conditions which are favourable to spermatogenesis (Setchell, 1998; Miesusset

Table 1: Indices of thermal differences between right and left scrotum in volunteers who assumed four different body positions during the study, naked then clothed ($n = 8$; Experiment I)

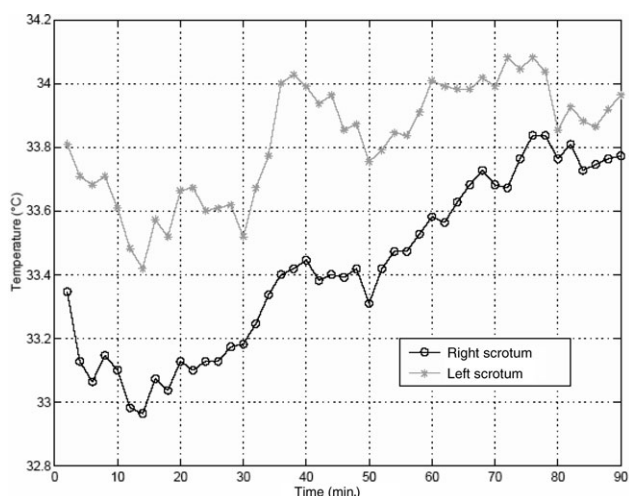
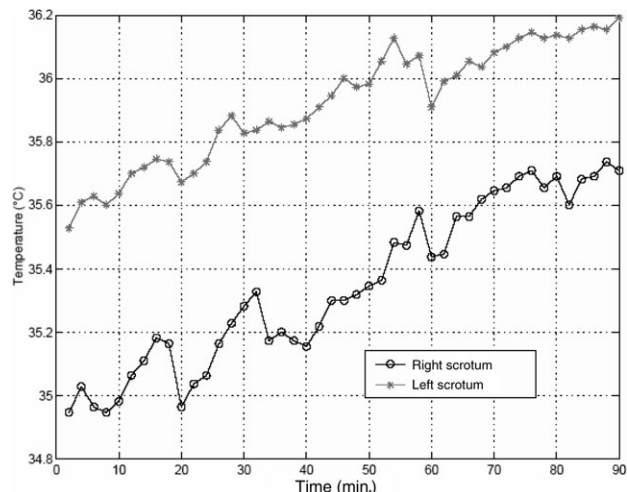
	Right scrotum	Left scrotum	<i>P</i> -value
Mean ratio of variation ^a (\pm SD)	71.62% (\pm 0.13)	46.37% (\pm 0.15)	0.008
Mean of the difference between temperature curves (right-left)	Naked	+0.25 (\pm 0.18)	<0.00001
	Clothed	-0.18 (\pm 0.14)	<0.00001

Values are mean \pm SD. T_s , scrotal temperature.^aIndividual ratio of variation = (range when clothed/range when naked) = $((T_{smax} - T_{smin})_{clothed} / (T_{smax} - T_{smin})_{naked})$

and Bujan, 1995), several mechanisms can be proposed to explain the difference in temperature observed between right and left scrotum. First of all, these can be assumed to include three extrinsic factors (i.e. not associated with the scrotum).

The first is the usual position of the penis that has a higher temperature than that of the scrotum (Hsiung *et al.*, 1991). In the clothed state, the penis is positioned on the left scrotum in 89% of cases (Bogaert, 1997). It would be worth taking this factor in genital asymmetry into account in future studies.

Secondly, it is known that genital asymmetry exists at the level of testicular volume as well, with the left testicle being 7–10% smaller than the right testicle based on post mortem measurements (Chang *et al.*, 1960; Johnson *et al.*, 1984). Jung *et al.* (2005) found no correlation between testicular volume and scrotal temperature. However, interpretation of the results is limited by the imprecise nature of the measurements of volume obtained with the Prader orchidometer, which would not appear to be the most appropriate tool for assessing testicular volume in adults (Steen, 1988). Because an evaluation of testicular volume was done with a Prader

**Figure 2:** Changes over time in right and left scrotal temperature in postmen ($n = 11$; Experiment II). Each point represents the mean of each measurement performed in the 11 men. Each man is active for 90 consecutive minutes in the standing position with short periods of movement inside a large room**Figure 3:** Changes over time in right and left scrotal temperature in bus drivers ($n = 11$; Experiment III). Each point represents the mean of each measurement made in the 11 men. Each man drives a bus in a seated position for 90 consecutive minutes

orchidometer in Experiments II and III, we were not able to evaluate the link between testicular volume and scrotal temperature.

The third extrinsic factor consists of varicocele, the presence of which is associated with an elevation in homolateral scrotal temperature (Wright *et al.*, 1997). None of the men involved in the three experiments had clinical varicocele. We cannot exclude the presence of sub-clinical varicocele, since no ultrasound examination was performed, but no data exist on any association of sub-clinical varicocele with elevation in scrotal temperature.

Apart from the extrinsic factors discussed above, two intrinsic factors (i.e. relating to the scrotum) may contribute to this difference in thermal behaviour between right and left scrotum: scrotal blood flow and cutaneous heat receptors.

No data are available on scrotal blood flow in men. In animals relative scrotal blood flow increases in parallel to temperature when scrotal temperature exceeds 34°C (Fowler and Setchell, 1971; Waites *et al.*, 1973). However, no information is given on whether the measurements related to the right or left side.

Thermal receptors are located in the scrotal skin. Heat receptors are activated when scrotal temperature increases beyond a threshold value and trigger, at the local level, a relaxation in the smooth muscle cells of the dartos, vasodilatation in the scrotal vessels or even sweating (Waites, 1991). However, heat-sensitive cutaneous zones (heat receptors) are not evenly

Table 2: Indices of thermal differences between right and left scrotum in standing postmen ($n = 11$; Experiments II) and seated bus drivers ($n = 11$; Experiments III)

	Mean of the difference between temperature curves (right-left)	<i>P</i> -value
Postmen	-0.40 (\pm 0.14)	<0.000001
Bus drivers	-0.57 (\pm 0.09)	<0.00001

Values are mean \pm SD.

distributed and/or their activation threshold is not identical throughout all cutaneous fields (Green and Cruz, 1998). The hypothesis would be as follows: the left scrotum could have a lower density of 'heat receptors' and/or a higher activation threshold than the right scrotum, which leads to certain mechanisms (relaxation of the dartos, vascular dilatation and sweating) coming into play later on the left, resulting in a higher scrotal temperature on the left than on the right.

In conclusion, genital asymmetry, made up of the position of the penis and testicular volume, could also include a functional thermal difference between right and left scrotum. Future work should indicate whether this functional thermal asymmetry is a result of the other elements of genital asymmetry or if it originates from a specific mechanism, the functions of which remain to be defined.

From a practical point of view, it would appear necessary, in the present state of knowledge, to measure right and left scrotal temperature in all experimental or epidemiological studies dealing with the relationship between scrotal temperature and spermatogenesis or fertility.

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