# Genital heat stress and semen quality

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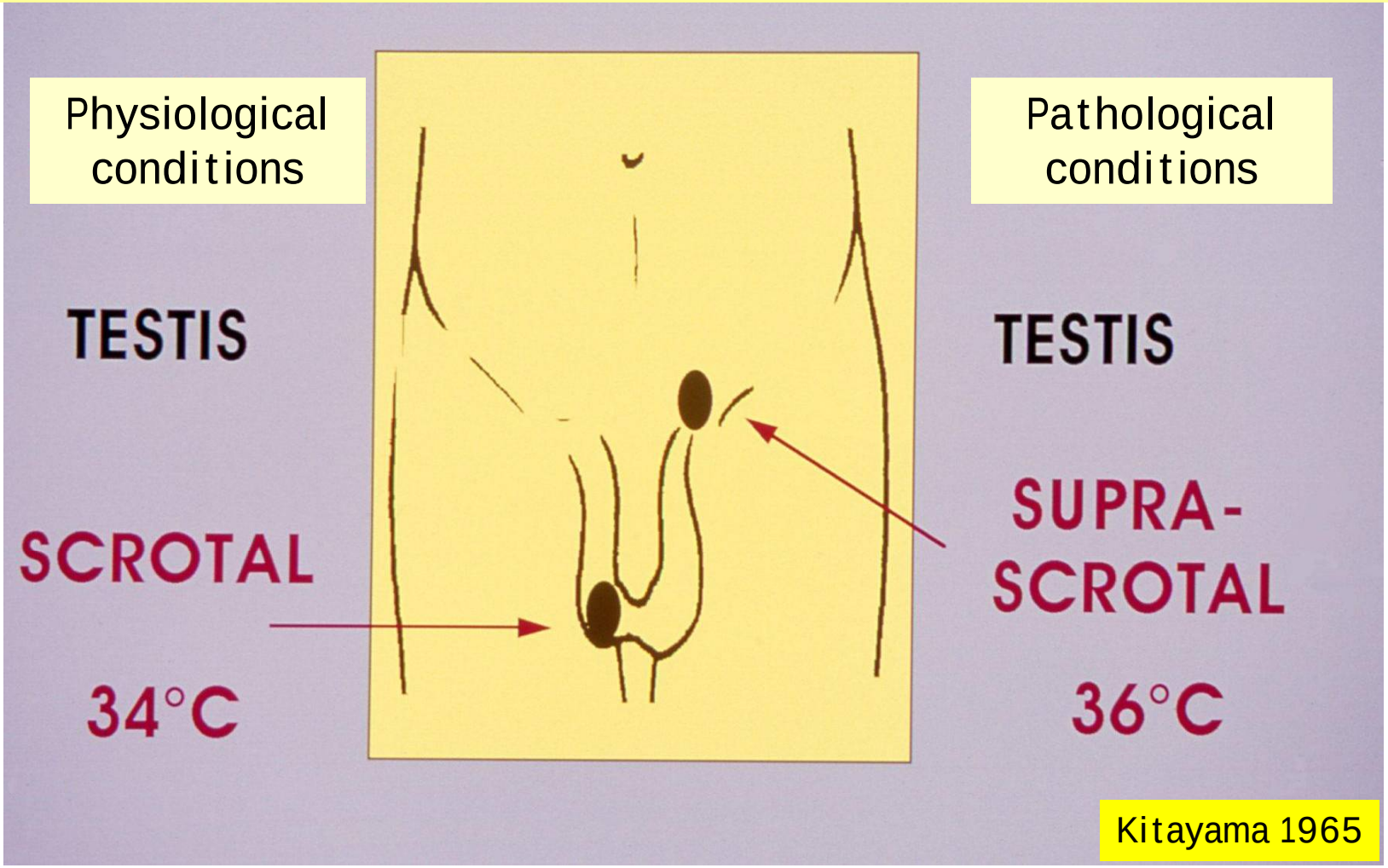
# What do we know about the thermodependence of the human spermatogenesis?

# Increase induced in human scrotal temperature

| Authors | Exposure characteristics | | Depression of total sperm count |
|---|---|---|---|
| Watanabe 1959 (n = 6) | scrotal bath 44 - 46°C Stp 42°C | 30 min/d 1 - 12 days | 60 % (week 5 to 12) |
| Robinson et al. 1968 (n = 14) | 150 w lamp 42.5°C Stp 42°C | 30 min/d 14 - 28 days | 40 % (week 4 to 9) |
| Robinson & Roch 1967 (n = 10) | scrotal insulation Stp: + 0.8°C | 15h/d (waking hours) 6 to 12 weeks | 50 % (week 3 to 9) 80 % (week 10) |

Stp = scrotal Tp

## Experimental data in humans: testis temperature



# Increase induced in human testicular temperature

Adapted from Mieusset et al, 1985

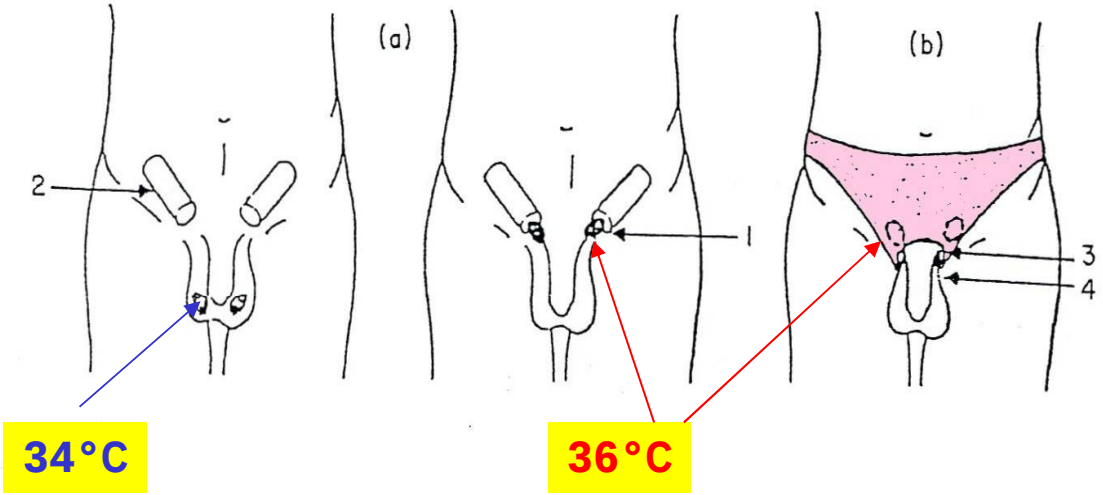



**Figure 1.** Techniques of heating the testes. (a) Testes are lifted up (1) close to the inguinal canal (2). (b) With technique 1, testes are maintained in the previous location by means of underwear in which a hole (3) was made at the level of the root of the penis. The penis and the scrotal skin are passed through this hole (4). (c) With technique 2, either a ring of soft rubber (5) was added to the hole in the underwear (4) or (d) this ring was worn alone (6), but maintained with thin straps (7).

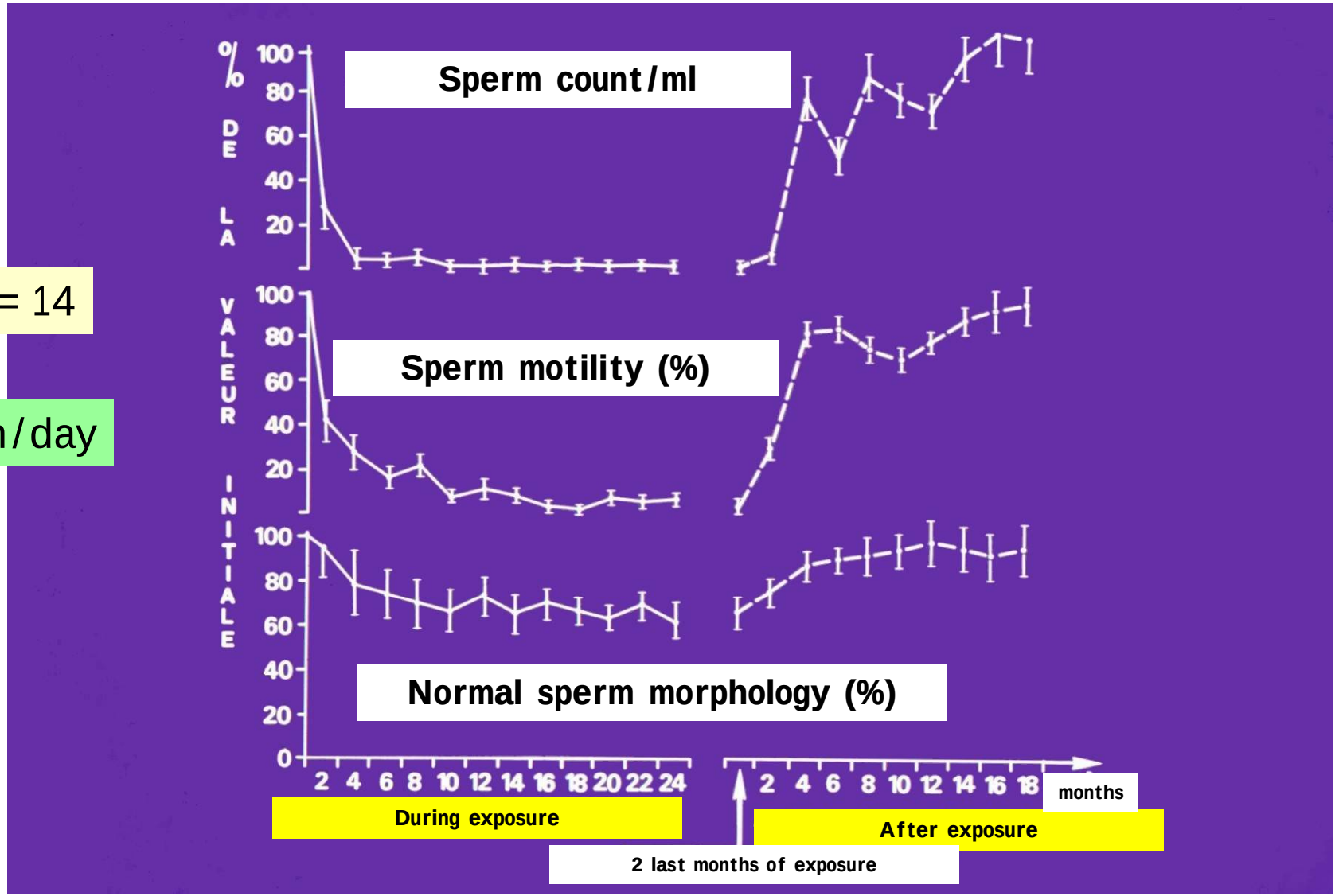
Effects on spermatogenesis of a 2°C increase in testicular in 14 volunteers?

15h/day

# Effects on spermatogenesis of a 2°C increase in testis Tp

n = 14

15h/day




Adapted from Mieusset et al.,1985, 1987

## What do we know about the thermodependence of the human spermatogenesis?

***Experimental studies inducing an increase in testis/scrotal Tp:***

1 A testis Tp = 36°C induces a depression in sperm count, motility and normal morphology

2 Such effects are obtained with both high (42°C) and low scrotal achieved Tp values (+ 0.8°C)

3 However the daily duration of exposure required for sperm alterations is:

short for high values (30 min/d; Stp = 42°C)
and longer for low values (15h/d; Stp = 0.8°C)

**Stp = scrotal Tp**

## Measuring temperatures: first step

Former data indicate that

- testis and epididymis represent the major thermal mass in the hemiscrotum, and
- intrascrotal subcutaneous Tps reflect Tp of the underlying testis.

Zorgnioti & McLeod 1973 n= 10 volunteers

undressed, lying in supine position or standing

10min acclimation room Tp 20-25°C

- Intrascrotal Tp: thermistor inserted subcutaneously near the upper pole of the testis (Rock & Robinson 1965)
- Scrotal skin Tp by scrotal invagination of the bulb of a specific mercury thermometer; accuracy =±0.05°C.

Good correlation between both values.

Scrotal skin Tp by scrotal invagination =

safe method for measuring scrotal skin Tp

## Measuring temperatures: first step

**Measurement of scrotal skin Tp by scrotal invagination.**

**Advantages**: main data source (1973-1990) for identifying in control conditions (room Tp, 10 min acclimation)

1. **Normal scrotal Tp** (Stp) values in normal fertile men: 32-35°C;

2. **Genital pathologies associated with abnormal Stp** (i.e. > 35°C):

- Testis maldescent, orchitis, varicocele: 25% general population
- Half with St > 35°C; associated with lower sperm count, sperm motility & normal sperm morphology (infertile men) than in men with normal Stp.

**Limitations: reproducible results only under static conditions**: lying in supine/standing positions - undressed for several minutes.

**Cannot be employed to evaluate dynamic processes**.

# Measuring temperatures: second step

Kurtz & Goldstein 1986 (n= 34 volunteers)

- intratesticular Tp with a needle thermistor
- scrotal skin Tp with a cutaneous thermistor

Good correlation between both values.

Jöckenhovel et al 1990 introduced a portable data recorder, which was connected with two scrotal skin thermistor sensors.

Thus, it became feasible to measure scrotal skin Tp under dynamic day-life conditions as read-out parameter for genital heat stress.

## Factors that contribute towards testicular heat stress

### Posture and clothing

Right and left scrotal skin Tps with cutaneous thermistors connected with portable data recorder

Experimental conditions:

- Lying supine, standing, sitting, walking postures
- Dressed/undressed

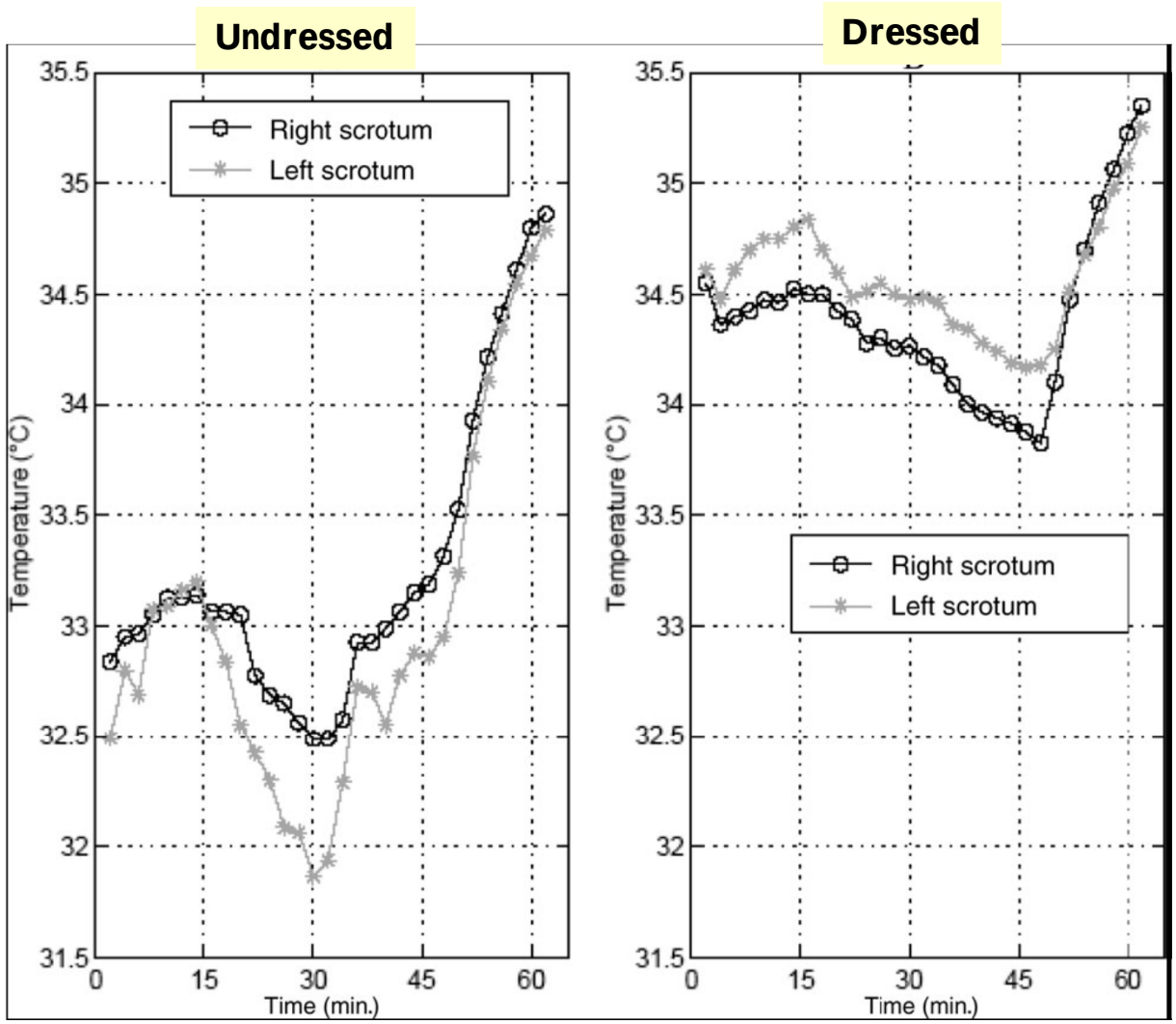
Real life conditions

- Sleeping and daily activities

**Cutaneous scrotal Tps n= 8 fertile volunteers** Room Tp 22.4-27.7°C

Posture and clothing

**Postures (15 min.):**
- supine
- standing
- seated with legs apart
- seated with legs crossed




Clothing vs naked state: + 1.5-2.0°C

**Bengoudifa & Mieusset, 2007**

Bujan et al, 2000

Mean ± SD

n = 9

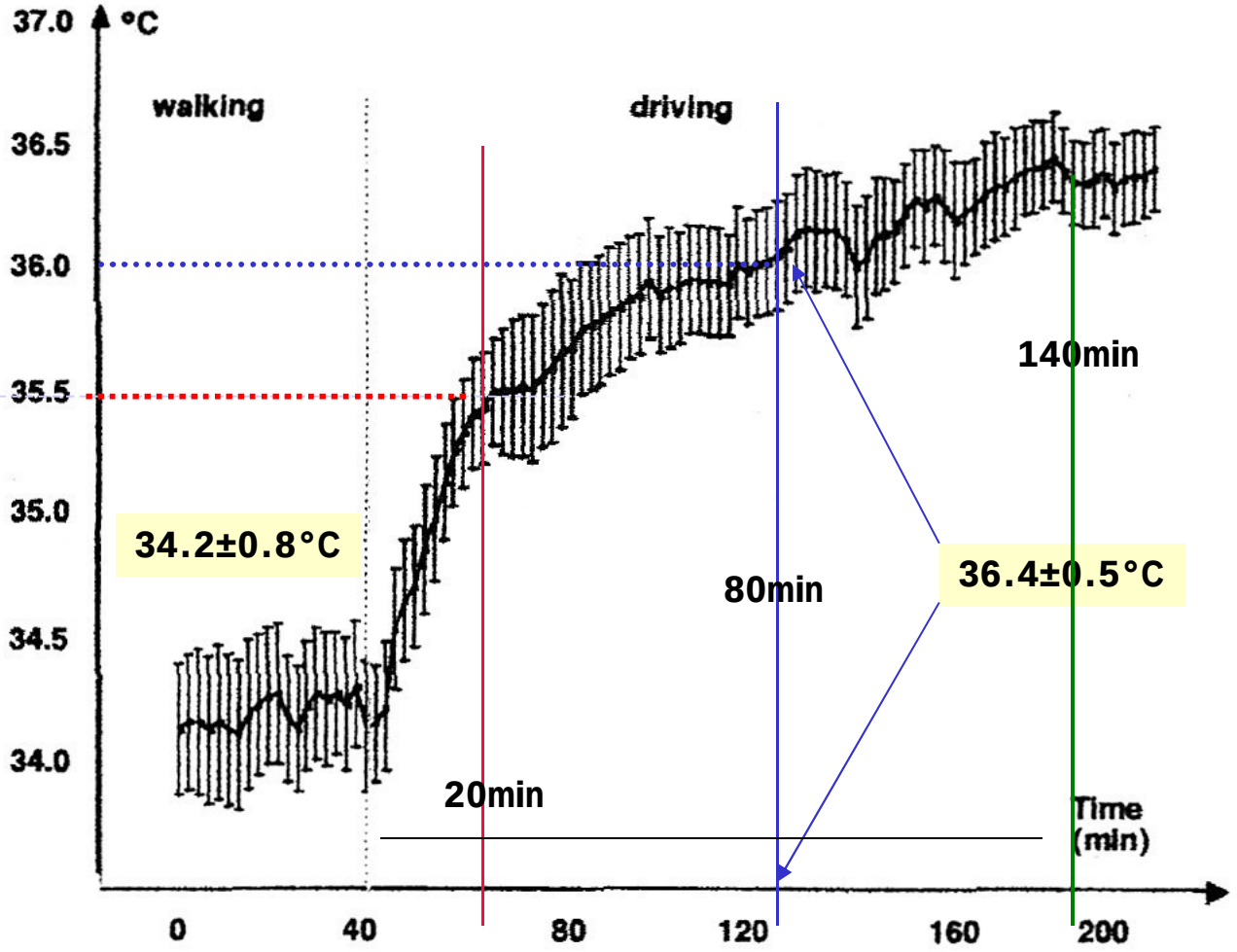


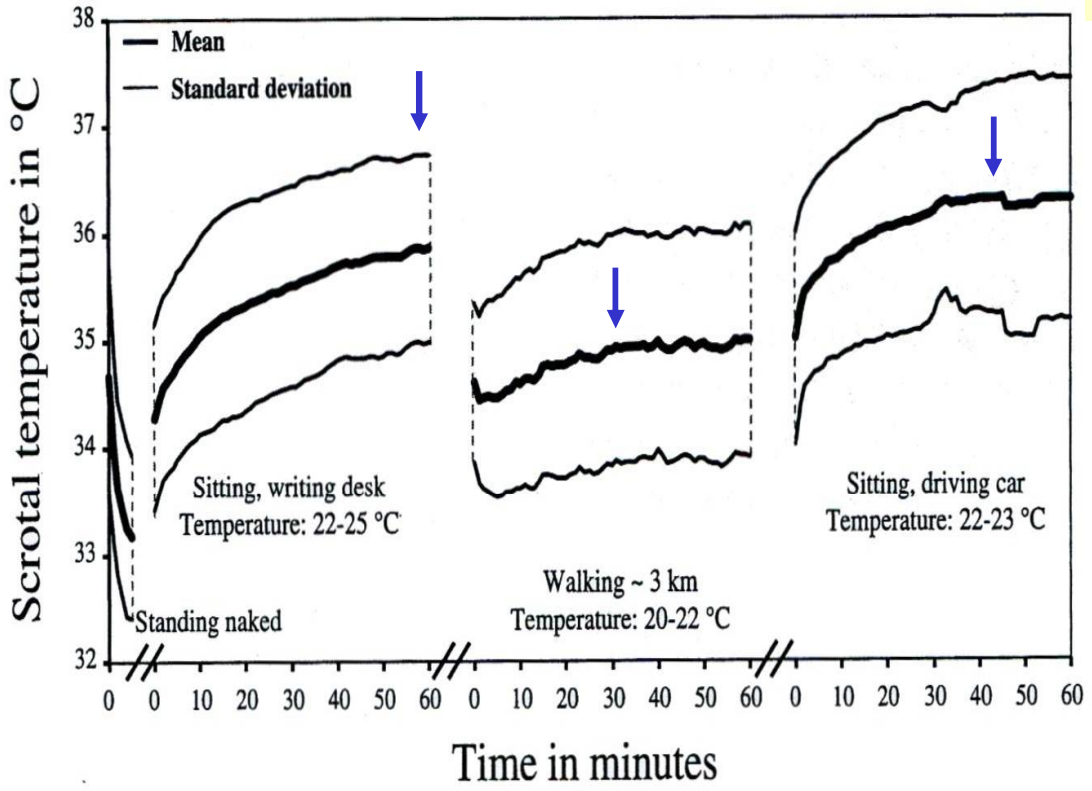

**Figure 1.** Mean right scrotal temperature in nine men while walking outside and driving a car.

Jung et al, 2001

Mean ± SD

n = 8

60 min

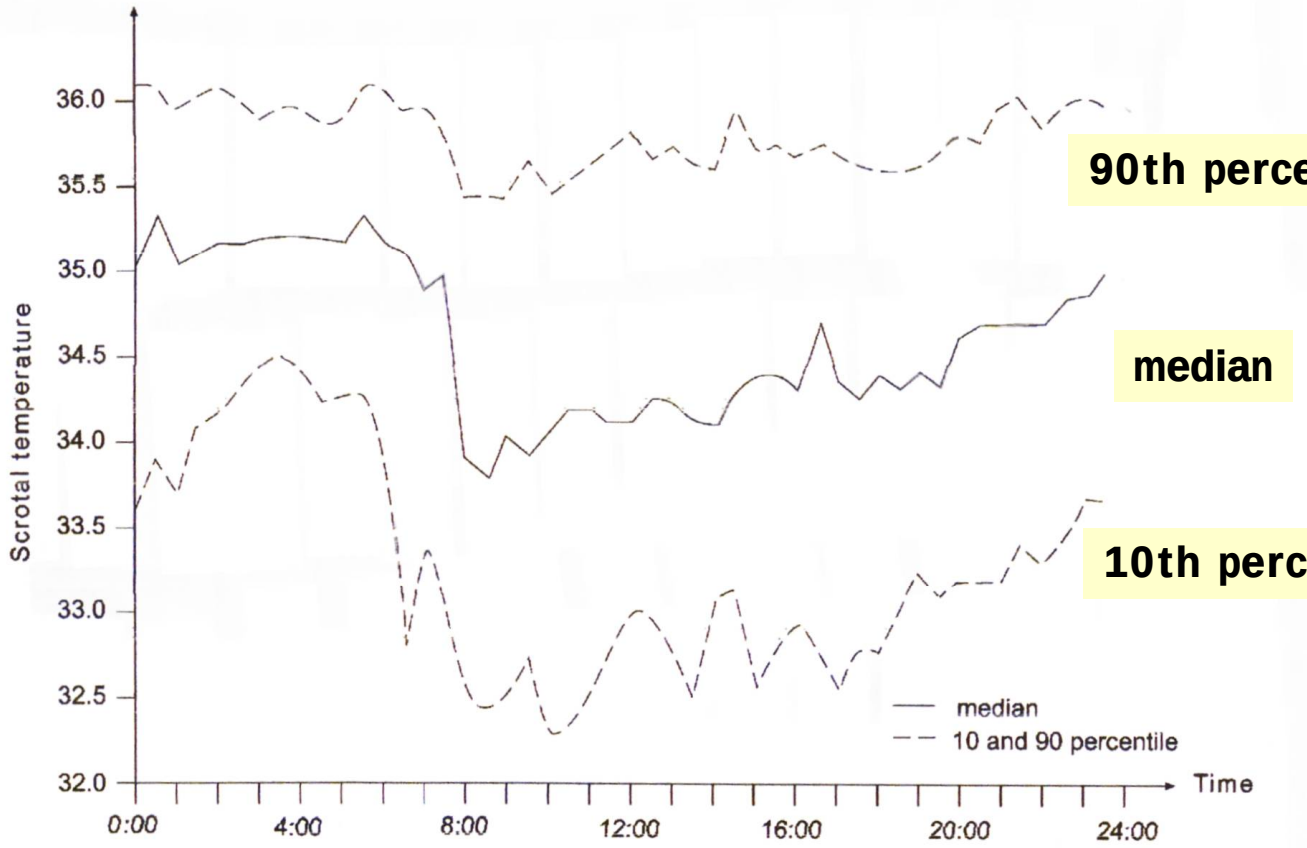



steady-state?

**Figure 1.** Influence of physical activity on scrotal heat dissipation. Standing naked for 5 min, 8 fertile men had scrotal temperatures that decreased rapidly to values below 34 °C. During 1-h phases of sitting at a writing desk or in a car, temperatures increased to values around 36 °C. In contrast, values were below 35 °C during the walking phase. *T*-test (paired, two-sided) for the last 5 min of exposure showed a significant difference between walking and sitting at a writing desk ($P < 0.01$) or in a car ($P < 0.001$), but not between the two sitting conditions ($P > 0.1$).

**n = 101; thermistor attached to the underwear: skin contact with the scrotum just between the caudal poles of the testes in an upright and supine position. Recording every 9 min.**

**Hjollund et al, 2002**




**90th percentile**

**median**

**10th percentile**

Fig. 2. Scrotal skin temperature during 24 h in 101 men. Median values and the 10th and 90th percentile of 0.5-h mean values.

Because of the individual variability in Stp within each time period, authors calculated 3 percentiles of Tp for each participant: the $10^{th}$ $50^{th}$ (median) and $90^{th}$ percentiles within each time period. Percentiles were treated as continuous variables.

**Thermistor attached to the underwear: skin contact with the scrotum just between the caudal poles of the testes in an upright and supine position.**

Hjollund et al, 2002. **n = 99/101; 1 day recording; semen collection**

A negative correlation between high scrotal Tp and sperm output;

Sperm concentration decreased

40% per 1 °C increment of median daytime scrotal Tp (95% CI: 8-71%)

Hjollund et al, 2000. **n = 66; 3 days recording; semen collection**

Scrotal Tp: median value: 33.3 °C in daytime vs 34.8 °C at night.

No relation between night Stp values and sperm output.

Median sperm concentration:

men with more than 75% of daytime values > 35°C = 33 millions/mL

men with less than 50% of daytime values > 35°C = 92 millions/mL

## Factors that contribute towards testicular heat stress

Clothing vs naked state (mean +1.5-2.0°C)
(lying supine, standing, seated legs apart)

Sleeping = higher values than daytimes
(median +1.2°C 95%CI:08-1.2)

Daytimes:

- Walking 1h 3km = lowest values
- Standing
- Sitting 1h at a desk or driving a car = highest values

# Factors that contribute towards testicular heat stress

## Sauna Exposure

n = 10 volunteers; 2 sauna sessions (80-90°C, 20-30% humidity)
15 min/week for 3 months

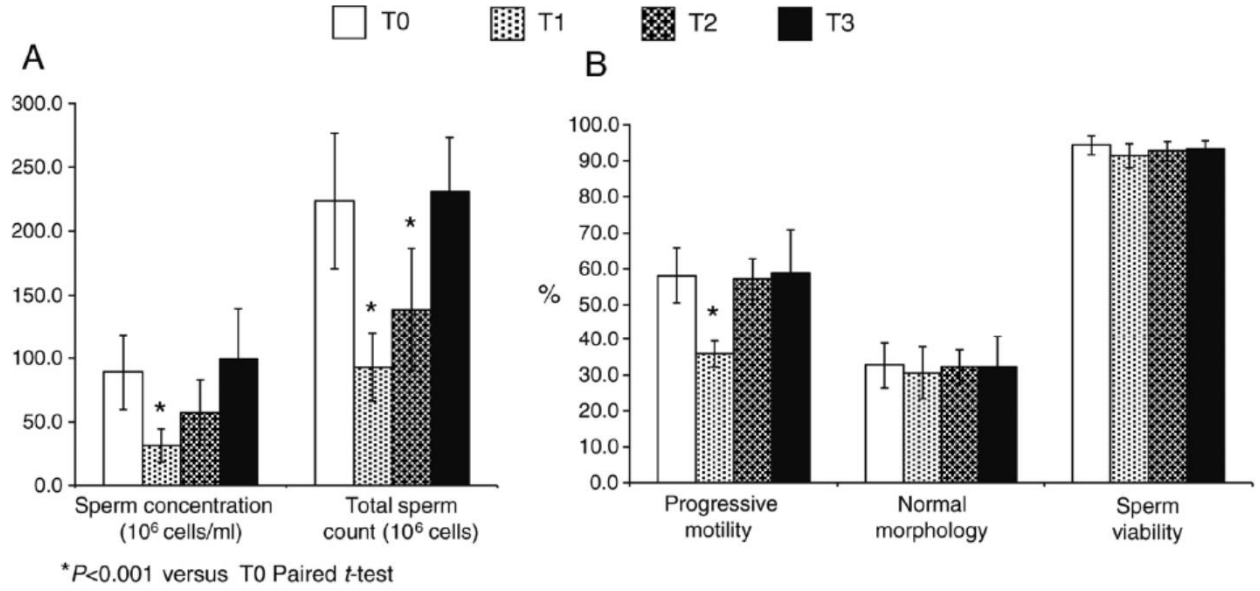


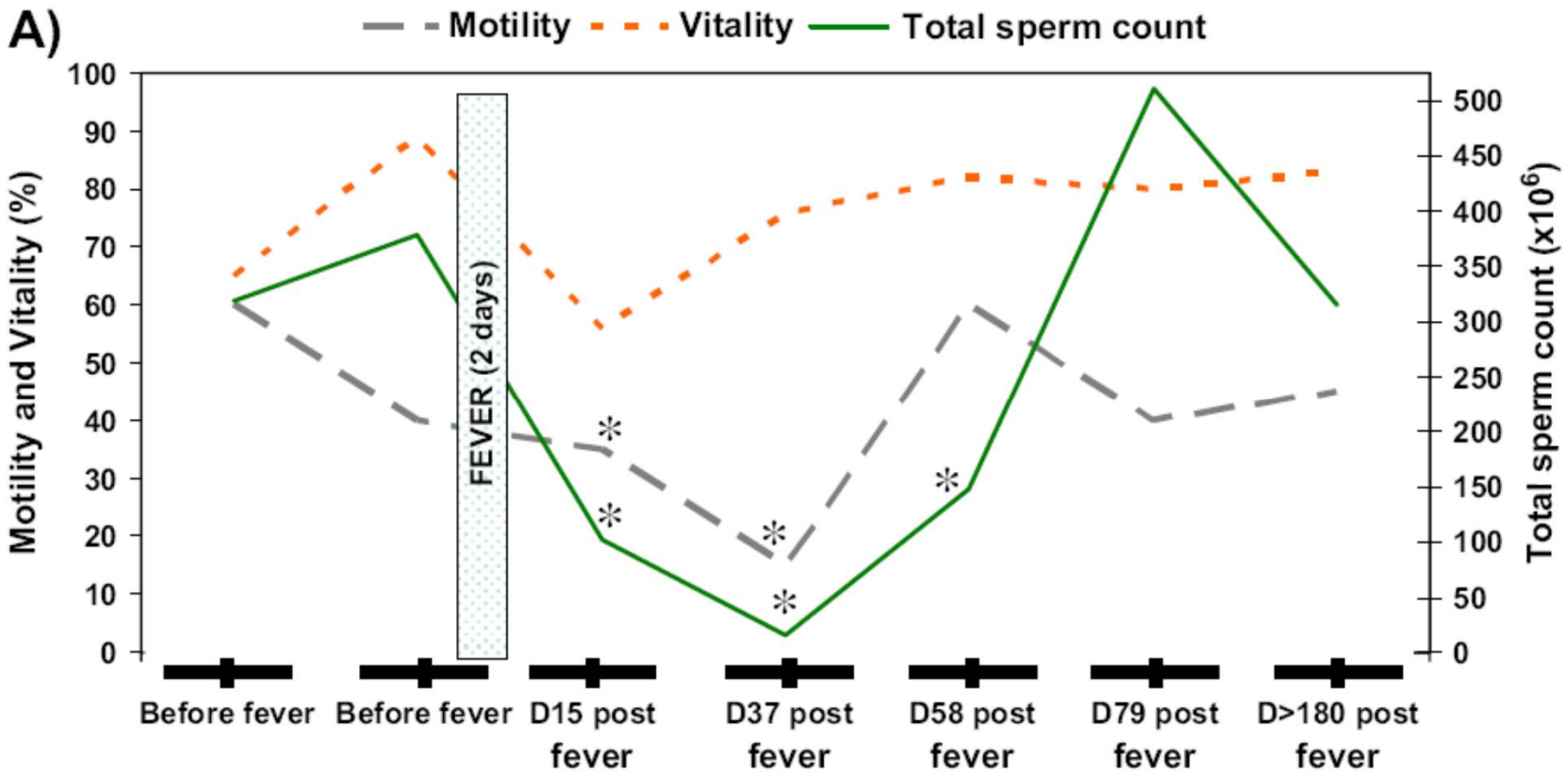

**Figure 2** Evaluation of sperm parameters during the whole study period: T0 = before sauna exposure, T1 = after 3 months of sauna sessions, T2 = after 3 months and T3 = after 6 months from the end of sauna exposure. Data are means ± SD, $n = 10$.

Garolla et al 2013

# Factors that contribute towards testicular heat stress

## Fever and sperm parameters

Impact of a 39°C fever for 2 consecutive days
in a sperm donor for research




Sergerie et al 2007

# Questions addressed by ICNIRP

**1. What are the thresholds for thermal damage?**

Both studies using either the invagination thermometer (static conditions) or scrotal skin thermistors (dynamic conditions in real life) during daytimes indicate

*scrotal Tp higher than 35°C as a risk factor for sperm output*

(i.e. a significant decrease in sperm output)

- when observed in 'basic conditions' as measured naked in supine after 10 min acclimation (room Tp 20-28°C) or

- when more than 75% of daytime values > 35°C.

## 2. Do such thresholds/relations depend on time?

Experimental studies with scrotal skin thermistors indicate that individual values during daytimes have a large variability with values ranging from 32 °C to 36.5 °C.

For each posture for 45-60 min - when dressed - a steady-state is achieved after 30 to 40 min.

(Jung et al. 2001, 2004, Koskelo et al 2005)

## 3. Is the 6-minute average currently used by ICNIRP for setting limits sensible in terms of the defined threshold?

For each posture for at least 45-60 min, a steady-state is achieved after 30 to 40 min.

Some authors used the mean values of the recordings for the first and the last 10 min to evaluate the thermal impact on scrotal temperature of a given factor (e.g. type of underwear) in a given posture.

(Jung et al. 2004, 2008)

## 4. Do such thresholds/relations depend on spatial extent?

e.g.: a particular temperature may not be harmful over a small (1g) volume, but if over the entire organ could it be harmful?

No experimental data in human testis to give a valid answer.

**5. Is the currently use of a 10g average when setting limits sensible in terms of the previous threshold/relation?**

Human normal testis volume ranges within 10 and 20 mL; which corresponds to a weight of about 10 to 20g.

The median testis weight is about 14g.

The answer could be yes.

## 6. Is thermoregulation sufficient for responding to local temperature changes?

The standard deviation of human scrotal temperature (Stp) values (around 1 °C) is surprisingly high in studies measuring Stp profiles under experimental conditions despite carefully controlling for potential confounders (Jung et al, 2005).

Possible explanation: genetic control of scrotal/testis regulation. (Hjollund et al 2005):

-Good correlation of Stp among 30 monozygotic twins

-No correlation in 18 dizygotic twins or single born brothers

Analysis (stepwise regression method) of factors influencing the upper range of Stp while driving a car (180 min). Identification of 2 factors (Bengoufida & Mieusset, 2006):

1. The initial Stp without thermal constraint;
2. The ability of the scrotum to adapt in abnormal conditions.

## 7. In terms of thresholds/relations above, how confident is science with this?

**Valid data**

1. Night temperatures: a significant role of genital heat stress causing deterioration of semen quality has to be denied (Hjollund 2003, Jung 2005).
2. Sperm density (millions/mL) decreased 40% by 1 °C increment of median daytime scrotal temperature.
3. A continuously achieved testis temperature to 36 °C for 15h/day induces a sperm quantity and quality deterioration as soon as day 45 (Ahmad et al 2012).
4. In induced increases in scrotal/testis Tp, sperm defects are always reversible when increases were stopped.

## 7. In terms of thresholds/relations above, how confident is science with this?

**Convincing evidence missing**

1. Duration of sedentary posture correlated with Stp; Stp negatively correlated with sperm density; sedentary posture & sperm density?

2. Available data are not yet sufficient to confirmed the assumed link between professional driving and sperm density/male fertility.

3. Both the use of portable computers in a laptop position (Sheynkin 2005) or using a heated car seat (Jung 2006) do increase Stp; effects on sperm quality remain to be conducted.

4. Wearing tight-fitting underwear is associated with increased Tp. A negative influence on semen quality remains to be proven.

**Stp = scrotal Tp**

**8. Are there thermal Standards/Guidelines in place to protect against such thermal damage?**

I do not know about.

## 9. If relevant how do such Standards/Guidelines deal with the multitude of variables that affect temperature?

Does it matter how the heat is generated,
or just the final temperature?

Just the final temperature.

However, wet heat is more harmful to the testis than dry heat by inhibiting one a major physiological scrotal response: evaporation of the local sudation.

## Important points (family jewels)

Threshold value = 35°C (R & L scrotal skin; cutaneous thermistors)

1. Personal histories/present pathologies susceptible to increase Stp ('basic conditions'; 6-min average OK)
2. Fever/sauna do impact spermatogenesis in the 3 following mths. The effects of an additive load of heat on an impaired spermatogenesis are unknown but will certainly induced an absence of sperm for a time.
3. Using 'basic conditions' will allow to select men at risk of a maximal detrimental effect of any additive heat genital stress.
4. If sperm count and motility do recover within 3 to 6 months after an achieved testis Tp, recent studies indicate others anomalies (chromatin defects) that could be involved in the embryo development (+ potential the epigenitic effects).