ON THE ASSESSMENT OF THE ENVIRONMENTAL COMFORT IN OPERATING THEATRES.

Mettere il nome di chi presenta
The operating theatre: a very complex environment!

People having highly different needs

- the surgical team carrying out a demanding and very stressful job
- the anesthetized patient subject to liquid infusion.
Different needs of the surgical team

- positions with respect to the scialytic lamp
- task within the team

Clothing influences comfort degree

- in some operations surgeons and assistants wear plasticized non transpiring overalls and protective masks and caps;
- if X-rays are needed the surgeons must also wear lead overalls and lead thyroid collars and gloves;
The present work reports data obtained during an experimental campaign carried out in May 2005 at the SS. Annunziata Hospital in Cento (Ferrara, Italy).

The results highlight the different thermal stress conditions affecting the surgical staff and may be useful in developing a correlation between local and global comfort situations and the physiological parameters such as body temperature $T_{\text{skin}}$. 
The objective investigation:
pointed at measuring several physiological parameters

- Superficial temperature $T_{\text{skin}}$ for each member
- Relative humidity between skin and overalls in order to define the condition of sweating for each member

The subjective investigation:
pointed at determining the comfort or discomfort sensations felt by the staff members on duty in the operating theatre.

For this purpose each staff member was given a questionnaire to be daily filled at the end of each operation.
Objective Investigation:
Physiological Parameter Measurement

Traditional wired systems would hamper the surgeon’s movements.

Then it was decided to use *i-Button* sensor/recorders produced by Dallas Semiconductors for temperature and relative humidity.

**DS1921H and DS1923 (Hygrochron) iButton Sensors**
Characteristics:

- compactness (diameter 17 mm, thickness 6 mm)
- capacity of up to 4096 records
- Acquisition rates from 1 second to 273 hours
- starting instant defined by the user or tied to an alarm condition
- memory space for individual calibration data
- password protection
- specific Identifier for each unity
- PC communication interface only uses one active wire (OneWire protocol)

The model DS1921H is particularly suited to monitor body temperature with resolution of 1/8 °C in the range +15 /+64 °C

The model DS1923 has the same range and the resolution and is also equipped with a capacitive polymeric sensor for measuring relative humidity with a 0.04% resolution.
The most reliable formulas for $T_{\text{skin}}$:

- Hardy and Dubois 1938  (1)
- Houdas 1982 (2)
- Olesen 1982 (3)

$$T_{\text{skin}} = 0.07 A + 0.35 D + 0.14 L + 0.05 M + 0.019 N + 0.13 R + 0.07 T$$  (1)

$$T_{\text{skin}} = 0.07 B + 0.17 E + 0.17 H + 0.19 J + 0.39 Q$$  (2)

$$T_{\text{skin}} = 0.5 D + 0.14 I + 0.36 S$$  (3)

where:

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Formulae (1) and (2) use points (forehead and cheek) that could hinder the surgeons’ work.

The calculated $T_{\text{skin}}$ values among the three different formulas do not vary in a meaningful way.

We use the Olesen’s formula (3).
The surgeon’s $T_{\text{skin}}$ ranges from 22°C for a simple operation (removal of a cyst in the hand) to 34°C for a more complex operation (knee prosthesis).
The different thermal condition experienced by the surgeons and assistants with respect to the nurses may be attributed to the position within the surgical area.
The type of clothing is another variable that must be taken into consideration.

Nurses generally use disposable or cotton jackets and trousers.

Surgeons and assistants wear plastic overalls, gloves, visors and in some cases, when the operation requires X-rays equipment, also wear lead overalls, gloves and thyroid collars.
The second surgeon’s $T_{\text{skin}}$ goes from 32 °C when he wore a non transpiring overall to 34 °C when he wore a paper transpiring overall, lead protection, gloves and protective cap. The stress condition is localized in the worker’s trunk as shown by the i-Button applied on the chest.
When $T_{\text{skin}}$ reaches values of about 35 °C, the relative humidity can reach the 100% in the air space between the body surface and the overall. It implies sweating and subsequent discomfort.
The higher stress conditions depend in a meaningful way from the type of worn clothing and on its thermal resistance, in fact the most intense sweating conditions correspond to the periods when the subjects wore lead overalls.
Subjective Survey:

Each member of the surgical staff member was given a questionnaire:

- the first part concerning the subjects’ physical characteristics (age, sex, weight etc...),

- the second part concerning the subjects’ job and clothing

- the third part (to be filled during or after working in the operating theatre) concerning the subject’s judgment on the thermal environment, the overall comfort sensations and requests of eventual changes of the microclimatic characteristics of the operating theatre.
Judgment on the thermal environment

- First surgeon = very hot 25% and hot 75%;
- Second surgeon = hot 50%, slightly hot 33% and neutral 17%;
- Surgical assistants = hot 67%, slightly hot 23% and neutral 10%;
- Nurses = neutral 75% and cold 20%. 
Overall sensation on the thermal environment

- First surgeon = discomfort 25% and slight discomfort 75%;
- Second surgeon = discomfort 33%, slight discomfort 50% and comfort 17%;
- Assistants = slight discomfort 90% and comfort 10%;
- Nurses = comfortable 75% and slight discomfort 25%.
Requested changes in the thermal environment

- First surgeon = cooling 100%;
- Second surgeon = cooling 68%, little cooling 15%, no change 17%;
- Assistants = little cooling 68%, no change 32%;
- Nurses = little cooling 9%, no change 68%; little heating 9%, heating 14%. 

SS. Annunziata Hospital
(May 2005)
Environment Change Request
Conclusions

The above report shows how difficult is to realize optimal conditions since the different metabolic needs and the different conditions of the surgeons, anesthetists, nurses and in particular of the patient undergoing surgery must be respected at the same time.

The survey methodology described above and the experimental data gained during the measurement campaign still ongoing at SS Annunziata Hospital in Cento (Fe) and Sant’Anna Hospital in Ferrara highlighted the correlation between the comfort/discomfort sensation manifested by the different surgical staff members, the specific tasks and the clothing worn by each one of them.
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