PERCEPTION OF THE THERMAL STATE OF THE BODY AND SKIN TEMPERATURES OF SEDENTARY HUMANS EXPOSED, TO UNIFORM INDOOR CLIMATES WITH DIFFERENT CLOTHING ENSEMBLES.

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INTRODUCTION

The temperatures at which the skin surface of resting humans lies depend among other things on the environmental conditions which momentarily prevail and on the clothing worn. The aim of the present study was to collect reliable data in the case of uniform and constant climatic conditions, to which sedentary human subjects (Ss) were exposed for several hours, dressed in clothes which corresponded to different levels of thermal insulation. Simultaneously, the global and local perceptions of the thermal state were obtained and compared to skin temperature data.

METHOD

Three levels of clothing insulation were selected : 0.1 Clo (unclad Ss) - 0.6 Clo (KSU uniform) - 0.85 Clo (T-shirt, long-sleeved shirt, pullover, double-layered trouser, socks and slippers).

In addition, sub-series of climate x clothing conditions had to induce thermal states of the body which were expected to be thermally judged as globally the same. In one sub-series, the judgment should be neutral (PMV = 0) (1). The following combinations were predicted to result in such "equicaloric" conditions: 28.1°C, with 0.1 Clo - 25.0°C, with 0.6 Clo - 23.3°C with 0.85 Clo, air velocity and humidity being held constant at 0.15 m/sec and 1.0 kPa respectively. In a second sub-series, the global judgment should be slightly cool (PMV = -1), which should be achieved at 25.8°C, 21.4°C and 19.0°C respectively ("infracaloric" conditions). In the last sub-series, the global judgment should be slightly warm (PMV = +1), reached at 30.5°C, 28.6°C and 27.7°C respectively ("supracaloric" conditions).

12 young paid volunteers stayed for 170 minutes in each of the nine climate x clothing conditions, after a 75-min adaptation exposure to the corresponding "equicaloric" condition. They repeatedly judged their thermal State on 9-point perception scales at a mean 15-min interval, globally and locally (head, trunk, arms, hands, legs, feet). Skin temperatures were measured every minute at 10 sites, giving a mean skin temperature and estimations of the local skin temperatures of the same 6 parts of the body. All the sessions took place in the morning (08.00-12.05).

RESULTS

A preliminary observation concerned a slow but significant continuous decrease of the mean skm temperature with time for clad Ss in "equicaloric" conditions. The same occurred for the means of global thermal judgments in all the "equicaloric" conditions. Therefore, in this short paper, only data recorded for 5 minutes after an exposure of 115 minutes to the experimental conditions will be considered.

The table presents global results. The expected PMVs were always obtained. Associated with the observed thermal judgements, the mean skin temperatures appeared as being : a) very similar within a given PMV ; b) clearly differentiated between different PMVs. The clothing worn did not influence either set of data.

As for the means of local thermal judgments in the "equicaloric" conditions, 39% of them were on the cool side and 44% were on the warm side. No stable hierarchy emerged among them, including extremities ; also there was no clear-cut effect of the clothing factor, except for unclad Ss. In contrast, local skin temperatures displayed by unclad Ss were well ordered from head and trunk to legs and feet ; in clad Ss, the hierarchy was slightly modified, the trunk temperature becoming the highest and the hand temperature getting close to the temperature of the legs. But there appeared no relationship between both sets of data.

In the "infracaloric" conditions, 94% of the means of the local thermal judgments were on the cool side. The unclad Ss judged the head as being the least cool, the feet as being the coolest. The clothing slightly modified the hierarchy: the trunk became the least cool, whereas the hands were judged as cool as the feet by the Ss wearing 0.85 Clo. Local skin temperatures were always ordered from head and trunk to hands and feet. The clothing was related to progressive increases of the trunk and arm temperatures and to progressive decreases of the head, leg and foot temperatures. Both sets of data were in good agreement in all the "infracaloric" conditions.

In the "supracaloric" conditions, all the means of the local thermal judgments were on the warm side. The differences between the local judgments were only small and not significant, so that no clear-cut hierarchy

emerged, either for unclad or for clad Ss. Local skin temperatures were always ordered from head and trunk lo legs and feet. The clothing was related to progressive increases in the trunk and arm temperatures and to progressive decreases of the head and leg temperatures. As in the "equicaloric" conditions, there appeared no relationship between the two sets of data.

DISCUSSION

When expressing global judgments in "infracaloric" or "supracaloric" conditions, the Ss felt only slight departure from sensory thermal neutrality. In contrast, the concomitant mean skin temperatures showed clear and significant differences between the three sub–series of conditions. All these values were achieved after 2 hours of exposure; in fact, the evolution with time, although slow, was a factor for which due allowance had lo be made. It seemed lo influence the skin temperature more than the thermal judgments, as if some kind of sensory adaptation had taken place which progressively reduced the intensity of the sensation.

Reported values of the regression coefficient of the mean skin temperature M air temperature (2) were lower than those estimated on the present data at a given level of thermal insulation. A similar value for unclad Ss can be obtained from data published for Ss exposed to 20 and lo 30°C Tamb (3). Thus, there seemed to be a rather high sensitivity of the mean skin temperature to the ambient temperature variation in the range of 19 to 30°C, even when Ss were clad. The sensitivity of the global thermal judgments with respect to ambient temperature was as would be expected on the basis of previous studies ; it decreased as clothmg insulation increased. With respect to the mean skin temperature, the sensitivity of the global thermal judgments was independent of the clothing insulation (in the 0.1–0.85 Clo range).

Significant relationships between local thermal judgments and corresponding local skin temperatures appeared only in "infracaloric" conditions, where synchronous differences between mean local skin temperatures amounted lo at least 6.5°C. Analogous differences in "supracaloric" conditions were smaller (3.6°C at the most). It was as if some difference limen had not been reached.

CONCLUSION

The various climate x clothing patterns produced efficient compensations between ambient temperature and clothing insulation. Although the clothing induced obvious variations of the local data, more information is wanted before concluding. It should be noticed that comfort judgments were not considered in this analysis.

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Uniform climate conditions :		*infracaloric PMV=–1*	*equicaloric PMV=0*	*supracaloric PMV=+1*
ICL =0.1 Clo	Tamb,°C OMV,a.u. Tsk,°C	25.8 –0.8(±1.3) 31.8(±0.4)	28.1 –0.1(±0.7) 33.1(±0.4)	30.5 +1.3(±0.9) 34420.2)
ICL =0.6 Clo	Tamb,°C OMV,a.u. Tsk,°C	21.4 –1.3(±1.3) 31.9(±0.3)	25.0 –0.1(±0.5) 33.0(±0.5)	28.6 +1.0(±0.6) 34.4(±0.4)
ICL =0.85 Clo	Tamb,°C OMV,a.u. Tsk,°C	19.0 –1.0(±1.0) 31.7(±0.5)	23.3 –0.3(±0.9) 33.4(±0.6)	27.7 +0.7(±1.1) 34.5(±0.2)

Table : Observed thermal judgments (OMV) and mean skin temperatures (Tsk) in the nine climate x clothing conditions defined by the expected PMVs, the ambient temperatures (Tamb) and the insulations of the clothing worn (ICL). Means (and s.d.) for 12 subjects.