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A field study on thermal comfort in an Italian hospital considering differences in gender and age

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ABSTRACT

The hospital is a thermal environment where comfort must be calibrated by taking into account two different groups of people, that is, patients and medical staff. The study involves 30 patients and 19 medical staff with a view to verifying if Predicted Mean Vote (PMV) index can accurately predict thermal sensations of both groups also taking into account any potential effects of age and gender. The methodology adopted is based on the comparison between PMV values (calculated according to ISO 7730 after having collected environmental data and estimated personal parameters) and perceptual judgments (Actual Mean Vote, AMV), expressed by the subjects interviewed. Different statistical analyses show that PMV model finds his best correlation with AMV values in a sample of male medical staff under 65 years of age. It has been observed that gender and age are factors that must be taken into account in the assessment of thermal comfort in the hospital due to very weak correlation between AMV and PMV values.

1. Introduction

Thermal comfort is a condition of mind that expresses satisfaction with the thermal environment (BS ISO 7730, 1995). It is known that working in comfortable conditions increases both productivity and performance (Parsons, 2003), for this reason thermal comfort represents an important parameter in the building design process. Generally in the assessment of thermal comfort simple situations where one work activity is been performed at one work location are investigated; but there are some cases where people with different activities must coexist in the same thermal conditions and in this context it is difficult to achieve a thermal comfort which is suitable for all. The hospital is an example of thermal environment where comfort must be calibrated by taking into account two different groups of people: on one hand the patients, who generally have a low metabolic rate (Skoog et al., 2005), due to their immobility, that is, lying in bed and, in some cases, an increase of clothing insulation and, on the other, the medical staff, with a higher metabolic rate and a lower clothing insulation when compared to patients.

Other factors that contribute to differentiation between patients and medical staff are:

- the presence of pathologies and disabilities which may affect the thermophysiology, thermal sensation and may require the use of drugs for treatments; disabilities may also involve the use of technical aids (wheel chairs) that may also affect thermal comfort (Humphreys et al., 1998);
- differences in age. Some hospital wards are populated by the elderly. It is generally considered that the ability to thermoregulate decreases with age (Havenith, 2001). Furthermore they are known to have lower activity levels when compared to younger people, and that is the reason why they require higher ambient temperature to achieve thermal comfort in comparison with young adults at equal clothing levels (van Hoof and Hensen, 2006).

Patients and medical staff are closely connected, in fact the medical staff is required to ensure patients' health and safety for the duration of their stay in the hospital. Heat or cold exposure can compromise the medical staff performance, both in patient heavy manual handling operations and in those activities involving attention and mental focus, such as handling needles or distributing drugs (NSW Guidelines). The assessment of thermal conditions plays an important role in determining which critical settings can compromise medical staff performance.

Ergonomists, engineers, occupational health specialists, or other personnel who are involved in the assessment of thermal comfort,

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in terms also of deviations from an optimal thermal situation, can predict thermal sensation for the body as a whole by calculating the Predicted Mean Vote (PMV) proposed by Fanger (1970). Fanger derived his comfort equation by exposing college aged students to a steady state condition in a climatic chamber for a 3-h period in winter at sea level with standardized clothing and performing standardized activities. He then expanded his comfort equation into the current PMV model, described in ISO 7730 (2005).

The fact that patients can differ significantly from the sample of college aged students, tested by Fanger, prompted the authors to verify whether PMV model, which is likely to be the most widely used thermal comfort index for assessing moderate indoor thermal environment, is also suitable for patient population, that is a group with different needs and characteristics from those of medical staff, as described above.

It is known that there are issues concerning the reliability and validity of ISO 7730 (Olesen and Parsons, 2002):

- reliability is related to the reliability of ISO 8996 (2004) and ISO 9920 in the estimation of personal parameters such as metabolic rate and clothing insulation;
- validity involves the issue if PMV can accurately predict the Actual Mean Vote (AMV). Laboratory studies have often supported the validity of ISO 7730 (2005), whereas field studies have not (Olesen and Parsons, 2002). Furthermore, according to de Dear and Brager (1998), the PMV model fails significantly in naturally ventilated buildings. They assert that the heat balance model ignores the psychological dimension of adaptation, a factor that plays an important role in naturally ventilated building (de Dear and Brager, 2002).

Previous studies found in scientific literature, and conducted in hospitals in different countries around the world (Table 1), investigate mainly aspects which are related to possible differences in thermal sensations between medical staff and patients or to the correlation between PMV and AMV. However they do not focus on differences in gender and age. Previous studies considering these two factors (Tables 2 and 3) show that the effects of their influence on thermal comfort, at this time require further investigation.

The aim of this study is to verify if PMV can accurately predict thermal perceptual sensations, represented by Actual Mean Vote (AMV), of both medical staff and patients, through an appropriate statistical analysis in order to investigate the potential effects of age and gender.

2. Materials and methods

Data were collected between October and November 2011 in 8 wards of a public hospital located in a central region of Italy. Wards differ by number of occupants per room and exposition but they are all heated by cast iron radiators that do not guarantee an adequate air circulation. Some wards use air conditioning but during the measurements it was kept off.

Data collection was concentrated on one participant at a time. The procedure performed involves interviewing the subject (subjective measurements) and at the same time evaluating the environmental parameters around the subject (objective measurements).

There were 58 subjects interviewed, but PMV index was applicable for only 49 of them. In fact, for 9 of the patients, calculated values of clothing insulation proved to be out of the range fixed in ISO 7730 (2005) for the application of PMV index.

Table 4 shows subjects involved in the study grouped by wards and divided by gender.

2.1. Data collection

Objective measurements were carried out by collecting environmental data around the subjects interviewed and by estimating their personal parameters (metabolic rate and clothing insulation) in order to calculate the PMV index according to ISO 7730 (2005).

Table 1
Previous field studies carried out in hospitals.

Authors	Country and period of survey	Groups considered	Findings
Vergara and Lamberts (2001)	Brasil, summer 1999, winter 2000	Workers of hospital	No correlation between calculated PMV and thermal sensation reported by workers when fixed metabolic rate by ISO 7730 is used.
Hashiguschi et al. (2005)	Japan, during winter (year not specified)	Patients and Medical staff	Discrepancies in thermal sensation of patients and staff regarding air temperature and humidity.
Skoog et al. (2005)	Sweden, summer 2003, winter 2004	Patients and Medical staff	Differences between staff and patients in perceiving indoor temperature are greater in winter than in summer despite similar temperature.
Hwang and Chen (2010)	Taiwan, between January and June 2005	Patients	Represent the most extensive field studies of thermal comfort in a hospital. Results of chi-square tests reveal that physical strength has significant effect on thermal sensation but gender, age and acclimatization have not. Patients expected a warmer indoor environment rather than thermal neutrality. Regression model of AMV of patients on ET* indicated that patients thermal sensitivity is blunt.
Yau and Chew (2009)	Malaysia, period not specified	Medical staff	Higher comfort temperature is required for Malaysians in hospital compared with criteria specified in ASHRAE Standard (2003) and the significant deviation between Actual Mean Vote (AMV) and Predicted Mean Vote (PMV) strongly implies that PMV could not be applied without error in hospitals in the tropics.
Khodakarami and Knight (2007a,b)	Iran	Patients	In the first study, objective measurements of thermal comfort perception of patients in 14 hospital rooms are compared with the requirements of thermal comfort in standards. In the second study, authors try to answer to the possibilities to reconcile the different expectations of patients and staff towards thermal comfort within the same room. Authors suggest different zones for patients and for staff due to their different thermal comfort requirements.
Verheyen et al. (2011)	Belgium, March 2009	Patients	*t* Tests show no significant difference between PMV and AMV for all the wards considered except for neurology. The authors concluded that PMV may adequately predict the mean thermal sensation for the majority of patient population for the wards considered with the exception of the neurology ward.