Thermal Comfort Study in Portuguese Elderly Care Centers

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Abstract
Thermal environment in homes does not usually cause serious illness however it has a very significant impact on the general well-being and daily performance of its residents. Poor thermal environment can also aggravate the impact of air pollutants on occupant's health. This study was performed in 71 elderly care centers rooms both in winter and summer season. Thermal comfort parameters were measured following ISO 7730:2005, included relative humidity (RH), temperature and air velocity in order to determine predicted mean vote (PMV) and predicted percent of dissatisfied people (PPD) indexes. Mean radiant temperature, PMV and PPD indexes and the respective measurement uncertainties were calculated by Monte Carlo Method. The analyzed elderly care centers were naturally ventilated with no cooling systems apart from some passive measures, such as blinds and curtains on the windows. Our results point out that, due to poor insulation, the winter season TC parameters and indexes are not within the class A of ISO 7730:2005 reference (PMV: [-0.2; 0.2]; PPD: < 6 %). Also there are significant differences by season between PPD (P = 0.033) and PMV (P = 0.001) indexes when assessing the same rooms. In natural ventilated environments with poor insulation, the maintenance of a comfortable indoor environment for elderly populations can be a substantial challenge, especially in winter season.

Keywords – thermal comfort; predicted mean vote; predicted percent of dissatisfied people; elderly care centers; elderly quality of life.

1. Introduction

Thermal comfort (TC) is one of the indoor environment factors that affect health and human performance, being chiefly determined by temperature, humidity and air velocity. Though thermal environment in homes does not usually cause serious illness, it has a very significant impact on the general well-being and daily performance of its residents. Poor thermal environment can also aggravate the impact of air pollutants on occupant's health [1]. The present study explored season variations of TC parameters in 14 elderly care centers (ECCs) located in Porto, including predicted percent of dissatisfied people (PPD) and predicted mean vote (PMV) indexes. This paper presents the first TC results integrated in the GERIA Project 'Geriatric study in Portugal on Health Effects of Air Quality in Elderly Care Centers' ongoing study.

2. Materials and Methods

2.1. Sampling sites

The study was performed during winter 2011 (November-December) and summer 2012 (June-August), in 71 ECCs rooms within dining rooms, drawing rooms, medical offices and bedrooms, including the bedridden subgroup. TC parameters were measured following ISO 7730:2005, included relative humidity (RH), temperature and air velocity in order to determine PMV and PPD indexes. The assessment included daytime sampling (starting at 10 am), conducted in a discreet fashion in order not to disturb occupants' normal behavior. It was also performed a building characterization by an walk-through survey including the following information: type of building construction (concrete, masonry, etc.); thermal isolation of the building; characteristics of building envelope (type of windows and doors, presence of weather stripping, etc.); ventilation system (natural, mechanical, hybrid, etc.); types of indoor materials; use of gas burning appliances; evidence of dampness or mould; as well as ventilation practices (opened windows).

2.2. Sampling methods

ECCs rooms 'homogeneous' and steady-state environment were tested according ISO 7726:2005 specifications with TSI 8386A-M-GB thermo-anemometer. Moderate environments (class C – comfort standard) were considered. Objective physical data, including air temperature, relative humidity and air velocity were collected by Delta Ohm HD 32.1 - Data logger, placed at a height of 0.60 meters above the floor (sitting - abdomen level). All monitoring data were collected as close as possible to the center of the room, with the sampling points no closer than 1 meter to a wall, a window, a door or an active heating system. After 25 minutes equipment stabilization in each room, the measurements were recorded during 10 minutes. The data for each room was obtained using the software DeltaLog10 version 1.30. According to ISO 7730:2005 and confirmed by observation, elderly occupants' daily activity was considered to have a metabolic rate of 1.0 met (seated, relaxed) and their clothing a thermal insulation of 1 *clo* (underwear with short sleeves and legs, shirt, trousers, jacket, socks and shoes) in summer, and 1.3 *clo* (underwear with long sleeves, long trousers, long shirt, jersey, thermo-jacket, socks and shoes) in winter.

2.3. Data analysis

PMV and PPD indexes, mean radiant temperature (*tr*) and their measurement uncertainties were calculated by Monte Carlo Method using MatLab software. Expanded uncertainty was evaluated for 95% confidence interval based on probability distributions propagation of measurands obtained by multiple samples and considering instrumental uncertainty obtained from traceable calibrations.

Descriptive analyses were used to obtain insight into the ECCs characteristics and TC monitoring results. Paired t-tests were used to test for seasonal effects differences. A 0.05 level of significance was used for all analyses. All data were analyzed using IBM SPSS 20.0.

3. Results and Discussion

3.1. Elderly Care Centers

The 14 ECCs were located in an urban area of Porto, housing a total of 343 persons with a range of 7 to 136 occupants *per* building. Most ECCs (78%) were in older buildings (up to 60 years old) using stone masonry construction and single pane windows. All buildings had been adapted for the purpose of ECCs. Only 33% had insulation on the roof and walls. Most of the buildings presented leaks (67%) and condensation (56%) in interior walls and ceilings. Floor coverings were mainly wood, tile/stone or PVC. The ECCs were all equipped with heating systems (30% central heating and 70% gas and electric heaters). All ECCs were naturally ventilated with no cooling systems apart from some passive measures, such as blinds and curtains on the windows. All ECCs were smoke-free and 89% were near roads with heavy traffic.

3.2. Thermal Comfort Assessment

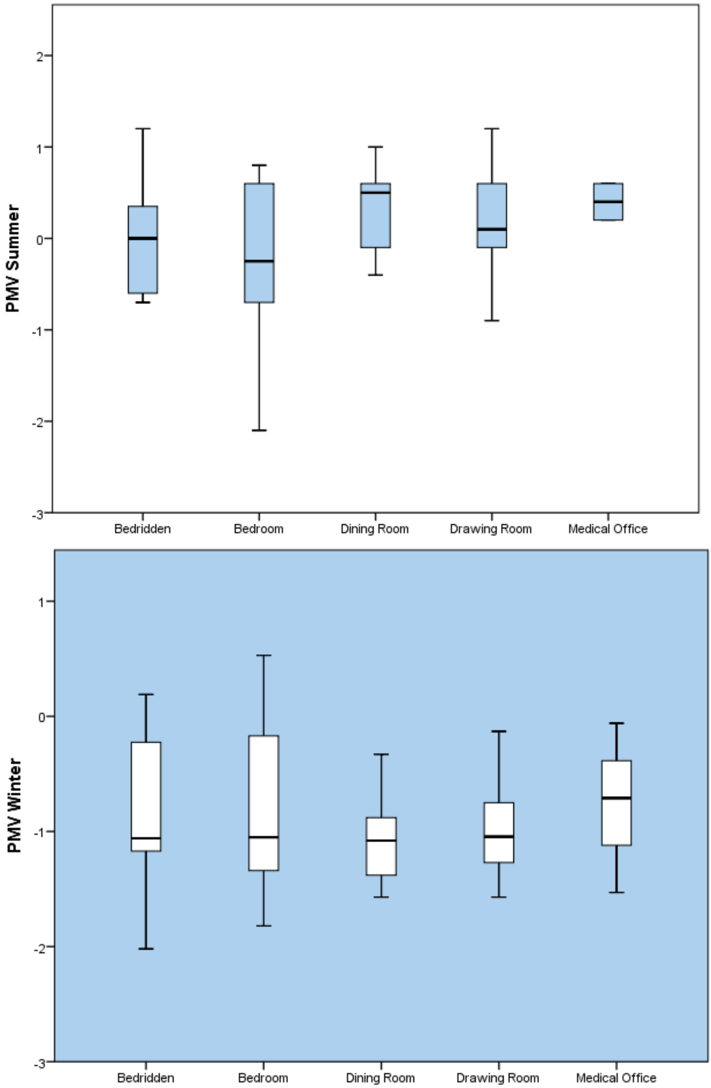
During monitoring, the mean daily ambient air temperatures in Porto ranged from 21 ºC (HR: 18%) to 30 °C (HR: 74%) in summer, and from 11 ºC (HR: 20%) to 21 °C (HR:72%) in winter. In the ECCs, temperatures ranged between 20 ºC (HR: 24%) to 28 °C (HR: 75%), in summer, and 14 ºC (HR: 26%) to 24 °C (78%) in winter. Table 1 presents the overall perspective of TC descriptive data of the main parameters assessed and associated variables. The room occupation was up to 21 persons in the summer and 30 persons in the winter seasons.

Figures 1a. and 1b. shows the distribution of PMV index around four out of seven values of the thermal sensation scale (1 = slightly warm; 0 = neutral; –1 = slightly cool; –2 = cool).
Our results point out that, due to poor insulation, the winter season TC parameters and indexes are not within the class A of ISO 7730:2005 reference (PMV: [-0.2; 0.2]; PPD: < 6%). Also there are significant differences by season between PPD ($P = 0.033$) and PMV ($P = 0.001$)

indexes when assessing the same rooms. In natural ventilated environments with poor insulation, the maintenance of a comfortable indoor environment for elderly populations can be a substantial challenge, especially in winter season. According to Raymann and Van Someren [2], TC is a major issue for the elderly and can be associated with cardio-mortality due to low temperatures in poor insulated houses [3]. Nevertheless these improvement measures should be tested for their consistency in the future if the ECC owners agree to implement them.

Table 1. ECCs main descriptive statistics and variables

	Minimum	Maximum	Mean	Std. Deviation
Air velocity $_{Summer}$ (m/s)	0.01	0.3	0.03	0.06
Air velocity $_{Winter}$ (m/s)	0.01	1.3	0.13	0.3
RH $_{Summer}$ (%)	24.0	75.2	53.7	12.5
RH $_{Winter}$ (%)	26.4	77.7	49.5	12.8
PMV $_{Summer}$	-2.1	1.2	-0.02	0.8
$U_{95\%}$ PMV $_{Summer}$	-0.50	0.20	-0.04	0.17
PMV $_{Winter}$	-2.4	0.5	-0.89	0.68
$U_{95\%}$ (PMV) $_{Winter}$	-0.48	0.39	-0.09	0.23
PPD $_{Summer}$ (%)	5.0	77.6	19.6	19.7
$U_{95\%}$ (PPD) $_{Summer}$ (%)	-1.90	18.40	2.56	4.34
PPD $_{Winter}$ (%)	4.4	91.5	29.9	22.4
$U_{95\%}$ (PPD) $_{Winter}$ (%)	-49.50	19.60	1.7	11.58
Temperature of air $_{Summer}$ (ºC)	16.3	27.6	23.08	2.9
Temperature of air $_{Winter}$ (ºC)	13.6	24.2	18.9	2.7
Globe temperature $_{Summer}$ (ºC)	15.8	27.5	23.2	2.9
Globe temperature $_{Winter}$ (ºC)	13.6	25.03	19.2	2.8
Operative temperature $_{Summer}$ (ºC)	16.0	27.5	23.2	2.9
Operative temperature $_{Winter}$ (ºC)	13.6	24.3	19.4	2.7
Tr $_{Summer}$ (ºC)	15.4	29.2	23.4	3.08
$U_{95\%}$ (tr) $_{Summer}$ (ºC)	0.00	0.30	0.05	0.07
Tr $_{Winter}$ (ºC)	13.6	27.9	19.6	2.9
$U_{95\%}$ (tr) $_{Winter}$ (ºC)	0.00	0.90	0.08	0.13



Figures 1a and 1b. PMV distribution by room and by season

4. Conclusions

Our study suggests that simple measures could provide health benefits to ECCs residents, such as insulating ceilings, walls and windows, without giving up the natural and passive ventilation solutions that are very common in Portugal due to the advantage of the country's generally mild weather. Further work is needed in order to analyze the interaction between TC variables within and between buildings, thus improving the wellbeing of our elderly population. As further development this study will add a thermal sensation questionnaire to collect subjective thermal sensation of the occupants, as well as, the comparison between measured and subjective PMV.

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6. References

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