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Older People, Thermal Comfort Behaviour and Related Energy Use

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ABSTRACT

This work investigated thermal comfort and adaptive behaviour of older people in their houses as well as the related energy demand during the summer 2020 and the COVID-19 situation in India, Turkey and the UK. Older people are considered, as less sensitive and responsive towards the changes of the thermal environment. Thus, their health is at risk, particularly concerning the climate change and the recent increase in heat waves. The use of control systems and the related energy demand was of particular focus in this work. Field test studies of thermal comfort using both longitudinal and transverse approaches were applied in India, Turkey and the UK. Overall, 1,273 datasets were included in this work. The comfort temperature was respectively 30.12°C, 24.88°C and 22.49°C. The comfort level of the Indian respondents was significantly decreased by the increased humidity levels, particularly the female respondents. Otherwise, the comfort temperatures of women were found similar to men. In Turkey and the UK, mainly natural ventilation and heating were in use. However, a variety of thermal control systems were available in the Indian case studies. Natural ventilation and fan were constantly in use, while more energy intensive systems, such as air conditioner, was only in use when outdoor temperatures reached 30°C and over. The energy use of the Indian case studies was found slightly lower than the British case studies, despite the availability of various thermal control systems.

Keywords: thermal comfort, energy, adaptive behaviour, thermal control, elderly, residential buildings

1. INTRODUCTION

A balance between energy and comfort is needed [1]. Occupants spend up to 90% of their time indoor [2] and this number is higher (closer to 100%) for older people [3], particularly during the COVID-19 situation. Thus, the quality of the thermal environment directly affects older people's health [4] and thermal comfort [5]. Also, space heating and cooling is responsible for 40% of the energy use in EU [6]. Longer occupancy periods require potentially higher energy demands to ensure the health and comfort of older people. Jiao et al [7] found that elderly prefer traditional methods (e.g. windows), as compared to air conditioner, to adapt to temperature changes.

The ability to thermo regulate the core body temperature is decreased in older people [8]. This is due to decreased ability in sweating [9,10] and lack of sensitivity towards temperature changes [11]. Thus, they are considered as vulnerable regarding temperature changes [12]. Extreme cold or heat can cause severe health related issues for older people [13-17]. While, enhancing the thermal quality of older people's houses improves their health and wellbeing [18,19]. Older people prefer to age in place and at their family residence [20,21]. Thus, extra care is needed in setting the thermal environment of older people's houses.

This work investigated thermal comfort and adaptive behaviour of older people in their houses as well as the related energy demand during the COVID-19 situation. Particularly, there was a focus on the impact of overheating in India, Turkey and the UK.

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2. RESEARCH METHODS

Field test studies of thermal comfort were applied during the COVID-19 situation between April and September 2020 in India, Turkey and the UK. Heatwaves were recorded with temperatures reaching respectively 47°C, 44°C and 34°C. The study included 1,273 datasets from 198 participants with a good balance of gender in transverse and longitudinal surveys of people over the age of 50. In the transverse survey (186 participants), an online questionnaire regarding thermal comfort and control was applied. The longitudinal survey included questionnaires (four times a day) and environmental measurements (e.g. dry bulb temperature, relative humidity etc). Overall, 1,087 datasets were collected from 12 participants in Turkey, India and the UK.

3. ANALYSIS

The indoor temperature (Ti) and relative humidity (RH) were significantly different between the three countries, as demonstrated in Table 1. The temperature ranges were approximately within 10°C in each country, with India having the highest temperature, Turkey in the middle and the UK having the lowest temperature ranges. The humidity level in Turkey was lower, in the UK it reached 74%, while in India it reached 85%.

Table 1 Indoor temperature and humidity ranges

Country		N	Minimum	Maximum	Mean	Std. Deviation
India	Ti	444	29	40	31.86	1.35
	RH	444	31.2	85	65.69	9.01
Turkey	Ti	421	23	33	27.02	1.9
	RH	421	28	60	45.87	4.71
UK	Ti	152	20	27	23.16	1.16
	RH	152	35	74	62.06	6.8

The overall mean average indoor temperature was 28.56°C. The overall mean comfort temperature was 26.81°C, as demonstrated in Figure 1. It was calculated using Griffiths method and 0.50 regression slope [22].

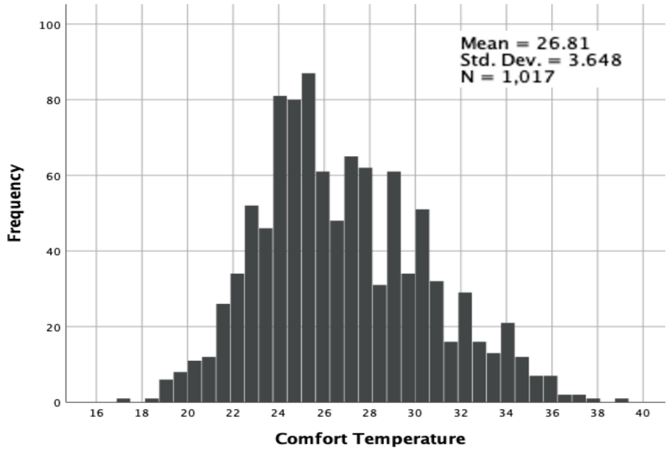

Figure 1 Overall comfort temperature

The mean average indoor temperatures in India, Turkey and the UK were respectively, 31.86°C, 27.02°C and 23.16°C. Significant differences were found between comfort temperatures of the three countries, respectively, 30.12°C, 24.88°C and 22.49°C, as presented in Figure 2. This was much higher than the ASHRAE Standard 55-2013 [23] and CIBSE Guide A [24]. The comfort temperatures worked better with the ASHRAE Standard 55-2017 [25]. Comparison between male and female responses showed very similar comfort temperatures in Turkey and the UK. However, the female comfort temperatures in India was 1°C lower than men's, as demonstrated in Figure 2. This is in disagreement with the current findings in the field, which suggest that women have higher comfort temperatures, as compared to men [26,27].

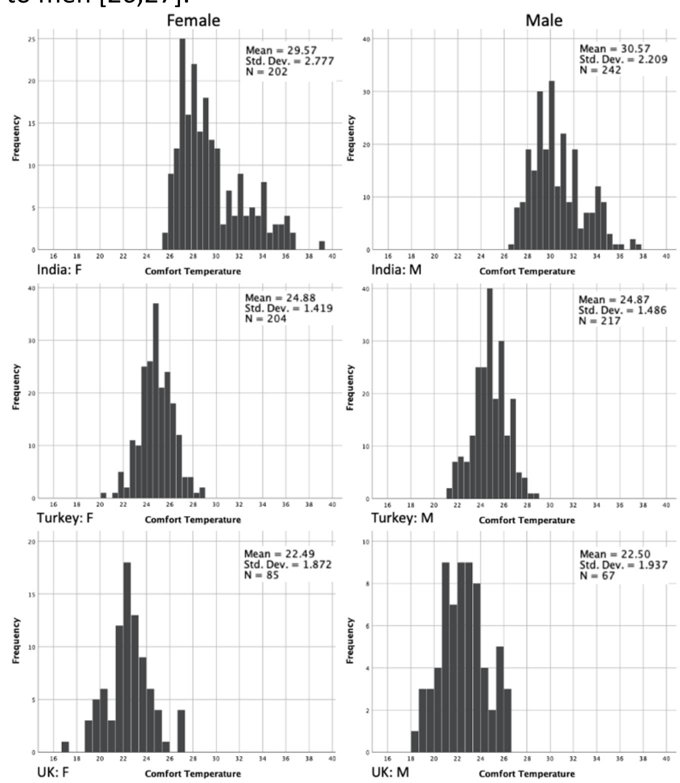

Figure 2 Comparing male and female Comfort Temperatures in India, Turkey and the UK

The Turkish and British respondents were less responsive to humidity. However, the Indian respondents were more affected by the humidity level. Particularly the female respondent was more sensitive to humidity, as compared to indoor temperature, as demonstrated in Figure 3. As the humidity dropped, the overall comfort level increased, despite the increase in the indoor temperature. Follow up interviews also suggested that dry heat is more tolerable, as compared with warm temperature and high levels of humidity.

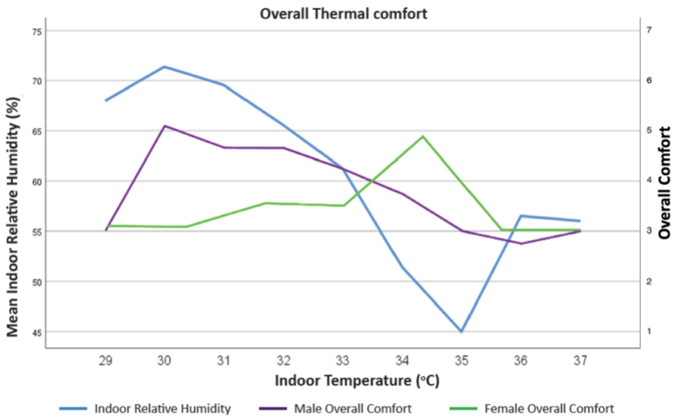

Figure 3 Overall comfort, temperature and humidity in India

According to the transverse dataset, a variety of thermal control systems were available in India, including openable windows, doors, fan, air cooler, air conditioner, and heaters, as demonstrated in Figure 4. Windows, doors and fan were constantly used, while air conditioner was in use, when outdoor temperatures were over 30°C. Heater and air cooler were hardly in use.

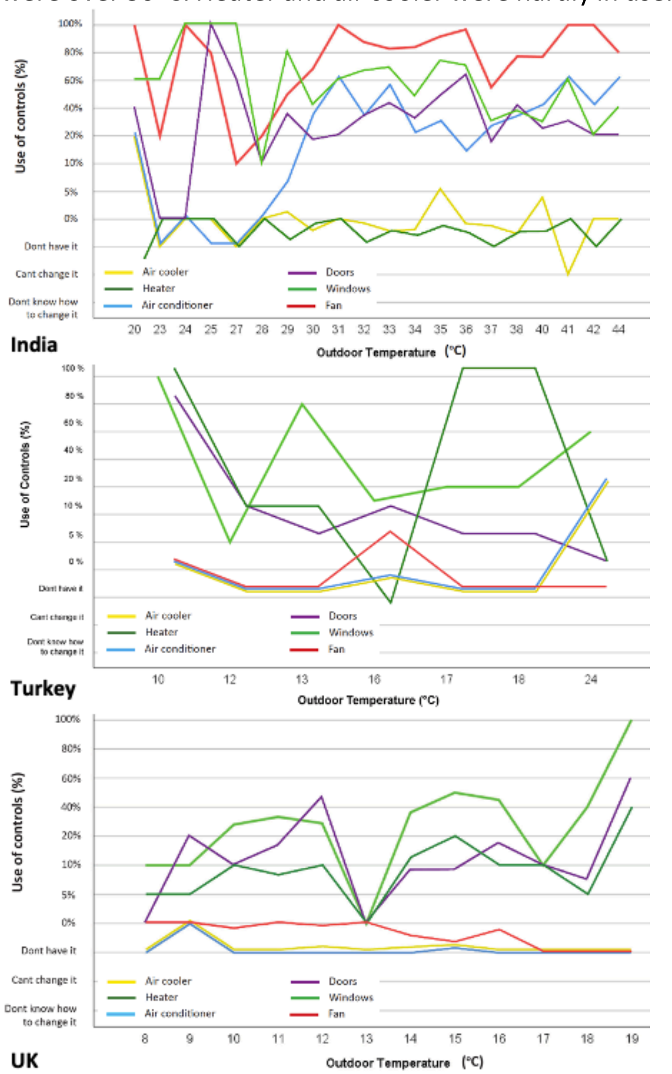

Figure 4 The use of thermal control in India, Turkey and UK

In Turkey and the UK, there were more limited thermal control available, as air conditioner, air cooler and fan were not that available. Mainly natural ventilation (windows and doors) was in use, particularly when the outdoor temperatures reached over 18°C. The heating was used in Turkey in temperatures below 20°C, while in the UK below 16°C. The mean average energy use in Indian, Turkish and British case studies were calculated as respectively, 351 kWh/m^2/year, 281 kWh/m^2/year and 370 kWh/m^2/year. This suggested that heating was the main energy demand in the Turkish and specifically British case studies. Although, the Indian case studies had access to a variety of thermal control systems, the energy intensive systems were only in use, when absolutely needed, while fans, which were effective and less energy demanding, were in use throughout the summer responding to a variety of temperatures. Thus, the energy consumption of the Indian case studies was relatively low, despite access to a variety of systems to manage the harsh temperature.

4. DISCUSSION AND CONCLUSION

The results indicated the following key findings:

- The comfort level of the Indian respondents was significantly decreased by the increased humidity levels, particularly the female respondents. This is in agreement with the findings of Kong et al. [28] suggesting relative humidities over 70% increases occupant discomfort.
- The comfort temperatures of women were found similar or lower than men. This is in disagreement with existing findings suggesting lower comfort temperatures for men [26,27].
- In Turkey and the UK, mainly natural ventilation and heating were in use, while other thermal control systems were not available. However, a variety of thermal control systems were available in the Indian case studies. Natural ventilation and fan were constantly in use, while more energy intensive systems, such as air conditioner, were only used when outdoor temperatures reached 30°C and over.
- The energy use in Indian case studies were less, as compared to the British case studies, despite the availability of various thermal control systems in India. The fan was the main mechanical system, which was used constantly with a relatively low energy demand.

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