Thermal comfort environment for migrants: a long-term follow-up climate chamber experiment

Yu Dong 1,2, Yuan Shi 3, Yanfeng Liu 3 and Jørn Toftum 1

1 Technical University of Denmark, Denmark
2 Xi’an University of Architecture and Technology, China
3 China Mobile Group Design Institute Co., Ltd, China

1,2yudo@byg.dtu.dk

Abstract. Migration between different climate regions may change people's thermal experience and their thermal adaptation. However, few studies have explored the thermal adaptation process and the suitable indoor thermal environment of migrants. In this study, we conducted a long-term tracking comparative experiment on thermal adaptation of migrants moving from severe cold (SC) regions, hot summer and cold winter (HSCW) regions, and hot summer and warm winter (HSWW) regions to cold region of China. A two-year climate chamber experiment was conducted to follow migrants' progressive thermal adaptation, such as different weeks, months and seasons after they migrated. The results show that the thermal sensation of migrants was significantly associated with their origin, the time after migration and air temperature. In addition, with the increase time after migration, the thermal sensitivity of HSCW and SC migrants showed a significant upward and downward trend, respectively. Two years after migration, the thermal comfort limits of migrants from SC, HSWW and HSCW were almost identical at 23.5-27.8°C, 23.8-27.8°C, and 23.5-27.6°C. The results provides insight to the progression of thermal adaptation and helpful to guide the design of indoor climate for immigrants with different thermal experiences.

1. Introduction

With the development of world cultural exchange, human migration is becoming more and more frequent. Based on the thermal experience accumulated in the original living conditions, migrants may change their thermal perception of the new living environment. It is important to create a comfortable thermal environment and understand the dynamics of thermal adaptation for migrants.

Most research has focused on regional differences of thermal adaptation of migrants [1]. Only little information is available on the long-term effects of different thermal experiences on human thermal perception. Luo conducted a thermal comfort experiment on southern migrants who lived in Beijing for one month and one year, and obtained the dynamic changes of thermal response in different adaptation stages [2]. In addition, a "demand factor" was established to describe the winter indoor thermal experience of migrants from North and South China [3]. These studies did not consider the thermal adaptive development under heat exposure.

This study aims to explore the thermal adaptation of migrants with different indoor thermal experiences in a longer-term climate chamber experiment.
2. Method
The climate chamber experiment was carried out in Xi’an, a cold region of China. The experiment was conducted from September 2016 to July 2018. Twenty repeated experiments were conducted on the 1st day, 4th day, 7th day, 9th day, 12th day, 15th day, 3rd wk., 4th wk., 3rd m., 4th m., 5th m., 7th m., 8th m., 9th m., 10th m., 11th m., 13th m., 16th m., 19th m. and 22nd m. after the migrants arrived to Xi’an. The subjects were divided in four groups, with origin in SC, HSCW, HSWW and Xi’an, respectively. SC and Cold zone have central heating system in winter, while HSCW and HSWW do not. Each group of migrants consisted of 5. The average age of the subjects was 22.3, the average height was 1.66m, and the average weight was 61.1kg. Seven conditions were set in the experiment: 18, 21, 24, 26, 28, 31, 33°C. Each condition lasted for 40 minutes. Subjects needed to wear clothing with a measured insulation value of 0.45 clo during the experiment. A questionnaire was filled in every 5 minutes during the exposure period, and the thermal sensation vote (TSV) was evaluated with seven point scale [4].

3. Results and Discussion
Figure 1 shows the change of subjects’ mean TSV with migration time under different temperature conditions. The TSV of the subjects is obviously different with the change of temperature conditions. Multiple linear regression analysis of TSV, migration origin, temperature exposure, migration time and their interaction showed that the thermal sensation of migrants was significantly associated with their origin, the time after migration and air temperature. Among them, the TSV of HSWW migrants (P < 0.05), HSCW migrants (P < 0.01), and SC migrants (P < 0.001) were significantly different from that of local people.

Figure 1. Mean TSV of migrants with migration time.

Figure 2 shows the logarithmic relationship between thermal sensitivity and time after migration. Thermal sensitivity represents the slope of regression relationship between TSV and air temperature at each time point. In the early stage of migration, SC migrants had the highest thermal sensitivity, followed by HSWW migrants. This may be due to the superior indoor thermal conditions in autumn and winter in the original residence of SC migrants, so that it is difficult for them to adapt to the current environment in the early stage of migration. With the increase of migration time, the thermal sensitivity of HSCW immigrants showed a significant upward trend, while that of SC migrants was the
opposite; the thermal sensitivity of HSWW migrants showed a slight upward trend. This suggests that the long-term comfort indoor thermal environment will weaken people's ability to adapt to the climate.

Figure 2. Thermal Sensitivity of migrants with migration time.

Figure 3. Thermal comfort zone of migrants.

Figure 3 shows the comfortable temperature range of migrants at different time after migration. During the first year, the migrants all showed seasonal adaptation to their current residence; for HSCW and HSWW migrants, the comfort threshold was lower in winter and higher in summer; for SC migrants, the opposite was true. In the second year of migration, there was no obvious seasonal difference in winter and summer comfort thresholds between HSCW and HSWW migrants. This suggests that migrants adapted to their new thermal exposure.

4. Conclusion
This study discusses the thermal adaptation of migrants with different thermal backgrounds in a long term climate chamber experiment. The conclusions are as follows:
- The TSV of migrants were significantly associated with migration origin, time after migration and indoor temperature.
- With the increase of migration time, the thermal sensitivity of HSCW and SC migrants increased and decreased, respectively. This suggests that the long-term comfort indoor environment will weaken people's ability to adapt to the climate.

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