

THERMAL RESPONSES OF KOREAN AND JAPANESE IN THERMAL ENVIRONMENTAL CONDITIONS USING FLOOR HEATING SYSTEM

A.Tamura and K.Fukai, Yokohama National University, Japan
C.S.Yoon and Y.S.Chung, Yonsei University, Korea

Introduction

Floor heating system has been known as a comfortable heating system, and research on floor heating thermal sensation has not only been acquired in Korea, but in Europe and Japan as well. And recently floor heating system is becoming more widespread in Japan.

For generations, Korean unlike Japanese lived in houses under floor heating system. Accordingly, thermal responses of Japanese are assumed to be different from that of Korean.

Therefore, the purpose of this study is to investigate the differences in thermal responses between Japanese and Korean according to the changes in thermal environmental conditions under floor heating system.

Experimental Methods

Experimental facilities and conditions

The experiment took place in an artificial climate chamber. The size of the laboratory, and the positions of subjects are shown in Figure 1.

Subjects were exposed to the following conditions: combination of air temperature of 21°C and 24°C, and floor temperature of 20°C, 28°C, and 31°C.

The relative humidity was maintained at 40%, the mean radiant temperature regulated equally to the air temperature, and the airflow was controlled to a stationary condition.

Table 1 shows the experimental conditions.

Table 1. Experimental Conditions

experimental conditions		floor temperature		
		no heating	panel heating	
		20°C	28°C	31°C
indoor air temperature	21°C	●	●	●
	24°C	●	●	●

Table 2. Physical Characteristics of Subjects

physical condition*	subject	age	height [cm]	weight [kg]
	Japanese		24.0	165.5
Korean		22.0	165.0	60.7
Average		22.6	165.2	58.2
clothing	0.8~1.0 clo			
activity	1.0 met (sedentary reading)			

*mean value

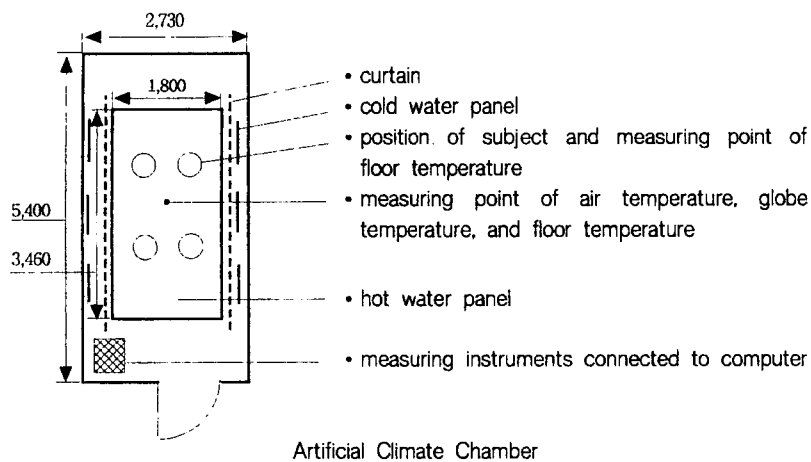


Fig 1. Size of Laboratory(unit: mm, scale: 1/100)

Subjects and clothing

Eight healthy Japanese and Korean(4 males and 4 females) in twenties were selected as the subjects. Their clothing and activity were all controlled. All subjects were seated on chairs facing the front wall and were clothed in shirts, trousers, underwear, and socks.

Experimental procedure

In order to study psychological responses of the subjects, thermal sensation, sensation of floor temperature and thermal comfort were examined. For physiological responses, epidermal temperatures(back of hand, instep, and sole) were measured. For 1 ½ hour the experiment took place in Yokohama National University in Japan during January and February, 1998. In order to stabilize the state of the subjects' body, the subjects stayed in the pre-test room(22°C, 40%RH) for 30 minutes before the actual experiment. Then they went inside the laboratory and stayed for 60 minutes. While the experiment was in progress, the subjects were to answer to the questionnaire every 10 minutes. The voting scales of psychological responses are shown in Table 3.

Table 3. Voting Scales

Thermal Sensation	Sensation of Floor Temperature	Thermal Comfort
-4 cold	-2 cold	-2 uncomfortable
-3 slightly cold	-1 slightly cold	-1 slightly uncomfortable
-2 cool	0 neutral	0 neutral
-1 slightly cool	1 slightly warm	1 slightly comfortable
0 neutral	2 warm	2 comfortable
1 slightly warm	3 hot	
2 warm		
3 slightly hot		
4 hot		

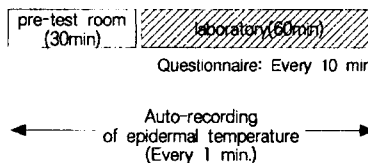


Fig 2. Procedure of Experiment

Results

Measurement of psychological responses¹⁾

1) Thermal Sensation

Figure 3 shows relationships between thermal sensation and floor and air temperatures for Japanese and Korean.

Both air and floor temperatures were found to influence the Japanese thermal sensations. On the other hand, only the air temperature was found to be the main factor influencing the Koreans.

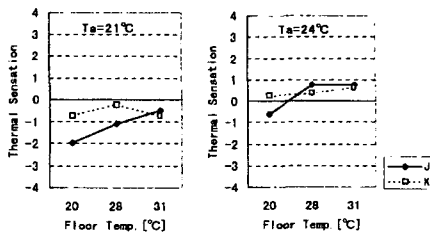


Figure 3. Thermal Sensation according to the floor temperature

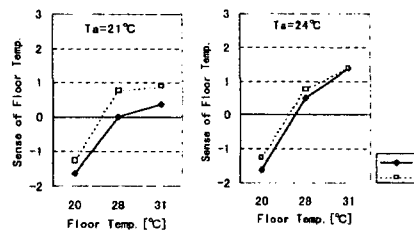


Figure 4. Sensation of Floor Temperature according to the floor temperature

2) Sensation of Floor Temperature

Figure 4 shows relationships between sensation of floor temperature and floor and air temperatures for Japanese and Korean.

For Japanese, sensation of floor temperature was influenced not only by the change in floor temperature but also by the change in air temperature.

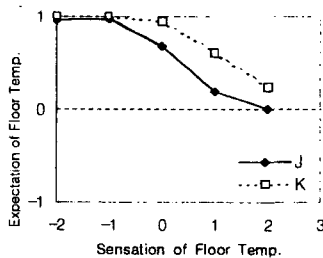


Figure 5. Sensation and Expectation of floor temperature

Figure 5 shows relationship between sensation and expectation of floor temperature²⁾ for Japanese and Korean.

It shows that Koreans prefer higher floor temperature than Japanese.

3) Thermal Comfort

Figure 6 shows relationships between thermal comfort, floor temperature and air temperature for Japanese and Korean.

Air temperature influenced the thermal comfort felt by the Japanese. On the contrary, floor temperature influenced the thermal comfort felt by the Korean.

Therefore, it is concluded that for Korean, floor temperature is a major factor influencing thermal comfort.

¹⁾ using mean value

²⁾ Expectation of floor temp.: '+1: want to make higher floor temp., 0: neutral, -1: want to make lower floor temp.,

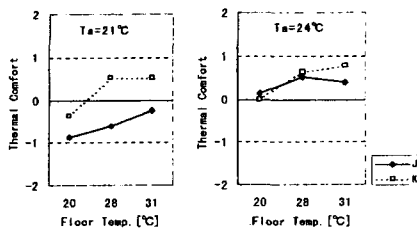


Figure 6. Thermal comfort according to the floor temperature

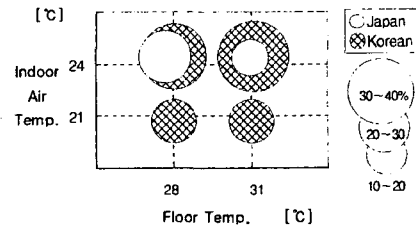


Figure 7. Comfortable Indoor Environmental Conditions

Figure 7³⁾ shows comfortable indoor environmental conditions for Japanese and Korean.

For comfortable indoor environmental conditions, Japanese chose air temperature of 24°C and floor temperature of 28°C. However, Korean chose 24°C for the air temperature and 31°C for the floor temperature. It thus proves that the Korean prefers higher floor temperature compared to Japanese.

Findings and Conclusions

1. For Japanese, thermal sensation is found to have been influenced by both air and floor temperatures, and thermal comfort influenced mostly by air temperature. For Koreans, on the other hand, thermal sensation is mostly influenced by air temperature and thermal comfort mostly by floor temperature. Judging from relation of sensation of floor temperature, floor temperature and air temperature for Japanese and Korean, it shows that Koreans prefer higher floor temperature compared to Japanese.
2. For comfortable indoor environmental conditions, Japanese chose air temperature of 24°C and floor temperature of 28°C. However, Koreans chose 24°C for the air temperature and 31°C for the floor temperature. It thus appears that Korean prefers higher floor temperature than Japanese.

Therefore Koreans, accustomed to floor heating, are found to be more sensitive to changes in floor temperature than to the changes in air temperature; in contrast, Japanese, not accustomed to the floor heating, are generally sensitive to the air temperature.

References

- Y.J.Choi(1996). Regulation and Comfort Zones on Indoor Thermal Environment of the Elderly. The Graduate School of Yonsei Univ.
- S.M.Lee(1992). An Environmental study on Establishing the Comfort Zone of Thermal Environment. The Graduate School of Yonsei Univ.

3) size of O(circle): [$\pm 2(\text{answer}) = 100\%(\text{comfortable/uncomfortable})$]

C.S.Yoon, B.H.Yoo and Y.S.Chung(1997). Development of Methods for evaluation of Indoor Thermal Environment of Apartment Housing. Journal of Korean Home Economics Association. Vol. 35, No. 6.

F.Kazuo and E.Kazuo(1997). Estimation of floor Temperature under Floor Heating System. J. Archit.

T.Shinichi(1990). Thermal Comfort Requirements of sedentary College-Age Subjects during the Winter Season in Japan. J.Home Econ.Jpn. Vol.41, No.5, 437-445.

T.Shinichi(1996). 住宅における温熱快適性の評価. 住宅総合研究財団研究年報, No.23.

Y.S.Choi, T.Horikoshi, S.Miyamoto and A.Mizutani(1996) Combined effect of air and heated floor temperature on man in Japanese sitting posture. J. Archit. Plann. Environ. Eng., AIJ, No.480, 7-14.