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# Indoor Thermal Comfort Characteristic Of The Living Space Of College Students

**HyunCheol Seo*, Yoonkyu Seo**

*School of Architectural, Civil, Environmental, and Energy Engineering,*
*Kyungpook National University, Korea*
*80 Daehakro, Bukgu, Daegu, Rep. of Korea*
**Corresponding Author, E-mail: notsools@gmail.com*

**Wook-Jung Na**

*Department of Fire and Disaster Prevention Engineering,*
*Changshin University, Korea*
*262 Paryong-ro, MasanHoiwon-gu, Changwon-si, Rep. of Korea*

**Kwang Woo Kim**

*Department of Architecture, College of Engineering,*
*Seoul National University, Korea*
*1 Gwanak-ro, Gwanak-gu, Seoul, Rep. of Korea*

## Abstract

Awareness of energy cost often causes inhabitants to create a rather uncomfortable thermal environment. The college students are normally not independent economically, they are considered to live in an uncomfortable environment. However, there is a lack of quantitative data required for improvement. This study analyzes the indoor thermal environment in the winter season depending on the awareness of energy cost of the residents in a college town and provides the quantitative characteristics of indoor thermal comfort. The research shows that the level of concern for cost has an influence on the indoor characteristics. It was found that most residents live in the environment relatively more uncomfortable than the standard environment.

**Keywords**: Indoor thermal comfort, College student, Cost Awareness

## 1 Introduction

The thermal environment of living space varies by individual [1]. The thermal environment living space is often determined by the resident's awareness of energy cost [2], as well as the individual's experience. Especially in the low-income group, it is reported that the awareness of energy cost causes uncomfortable thermal environment. In the same context, because most of the residents in the college town are economically dependent students, awareness of energy cost has a strong influence on the indoor thermal environment. However, there has been no quantitative data reported on the cost required to reduce the uncomfortable state. This study provides the quantitative characteristics of indoor thermal environment according to the cost awareness of the college town households.

## 2 Methodology

In this study measured the indoor thermal environment factors, such as air temperature and humidity, from 27 samples representing the college town households, and collected the room schedules, characteristics of residential buildings and characteristics of residents. We collected the indoor temperature and humidity values according to the HVAC control schedule of the college dormitories. The measurements were compared with the comfort zone suggested in ASHRAE-55[8]. Based on the characteristics of residents collected, we analyzed the distribution of the indoor environment according to the awareness of cost energy of the college town households.

To analyze the indoor thermal environment between the scheduled control and the cost-awareness-based control, we measured the indoor air temperature and relative humidity of a college dormitory with the scheduled HVAC control at an interval of 1 minute for a week. To acquire the data from households without dormitory, in this study purposively selected 27 households out of 81 random-surveyed households through literature review in consideration of gender and income level of resident, heating type and type of burden of energy cost, in order to consider individuals' experience that has influence on the indoor thermal environment. [3][4][5]

Experiments were conducted during the heating period (December ~ January). The air condition during the measurement period was temperature. max 4.9℃ ~ -5.4 ℃ (Avg 0.56℃, SD 2.32) and 75.3%Rh ~ 31.8%Rh (Avg 53.7%Rh SD 9.75).

The measurement was made at the resolution of 1 minute for at least 1 week per household. This study analyzed the indoor thermal environment of the college town households during the occupied period and the sleep period. In order to detect the occupation status and behavior in the room, we installed room sensors and conducted Time-Use Survey (Fig. 1) in which the residents recorded 10-min behavior on the diary. For the thermal environment in the dormitory, however, no time-diary recording was made considering that residents cannot control the indoor environment, but that the controlled environment is provided to meet the target comfort level.

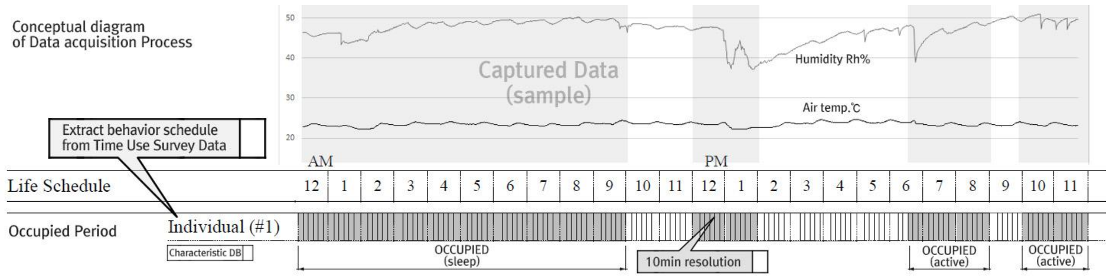


**Fig .1. Data acquisition process for this study**

## 3 Analysis of indoor thermal environment

The average room area of the household samples was 30.72 ㎡ (SD 12.77), and the average occupation per person per day was 11 hours and 33 minutes. The average room temperature and humidity of the investigated households were 19.83℃ (SD 3.27) and 53%Rh (SD 13.53), respectively. In this study, based on the average temperature and humidity of the residents, PMV indexes were estimated under the assumption of MRT equivalent to the air temperature, the air speed 0.1m/s, the metabolic rate 1.0, and the clothing level 1.0 (winter).

**Table 1. Group and the thermal environment depending on the forms of paying heating expenses**

| Group | Flag | Description | Avg. Air Temp(℃) | Avg. Humidity(%Rh) |
|---|---|---|---|---|
| A | O | No heating costs (included in rent) | 20.63 (SD 3.21) | 53.34 (SD 13.89) |
| B | ▲ | Heating costs borne by family (parents besr) | 19.37 (SD 3.64) | 53.89 (SD 12.87) |
| C | ■ | Heating costs borne by oneself (do part-time job, etc.) | 17.68 (SD 1.15) | 53.27 (SD 19.43) |
| D | ☆ | Controlled HVAC (University Dormitory) | 25.74 | 24.07 |

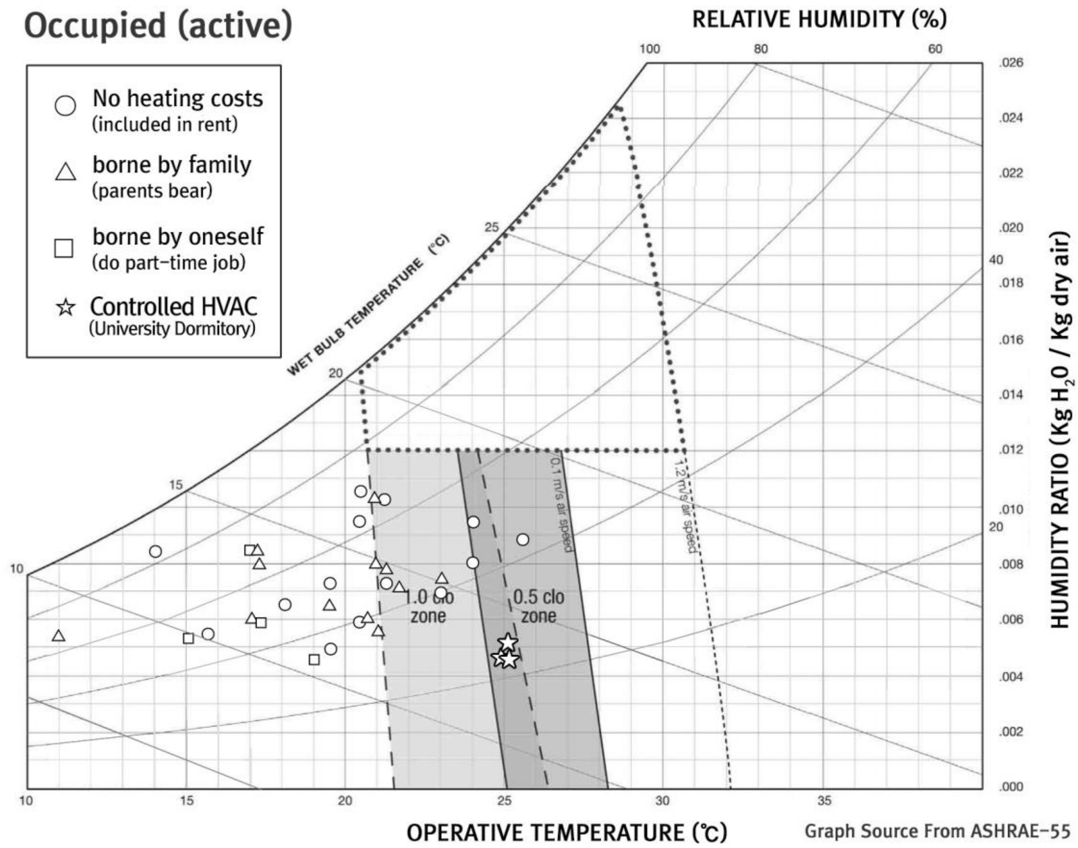


**Figure 2. Thermal environment distribution by forms of paying heating expenses**

This study derived the characteristics of the indoor thermal environment of college town households during the occupied period and the sleep period. The chart in Fig. 2 shows on which thermal environment the households occupy the rooms in comparison with the thermal comport zone suggested in ASHRAE-55 [4]. The average temperature and humidity measured are compared with the comfort zone by clothing conditions. Although the residents cannot control the indoor thermal environment, the controlled HVAC of university dormitory states are written for reference.

## 4 Result and Discussion

College student households are found to be slightly colder than the suggested comfort zone by a standard environment of ASHRAE-55 suggestion or the comfort zone reported in the academic circles. Table1 and Figure.2 provides the difference of indoor thermal environment found as a result of the analysis of a relationship between awareness of thermal cost and the thermal environment. No significant difference was found between the occupied period and the sleep period. The residents in a serious uncomfortable state, however, used auxiliary heating devices like electric pad during the sleep period for maintain body temperature. Distribution of the thermal environment according to the awareness of thermal cost shows that the most comfortable thermal environment is when the heating cost is included in the rental bill. In the college towns of Korea, leaseholders pay the heating cost in many cases. Considering that the measurement was made in the winter season (1.0clo), some households take the burden of excessive heating.

In case heating cost is at the burden of a third party (parents), the residents are also in a slightly cold environment on average. The time-use diary shows that these residents used auxiliary heating device like electric pad when they started the sleep behavior, and the monthly energy cost was 11.12USD/Month

## 5 Conclusion

The college student resides in the same area for over four years from the entrance to graduation and stay in the rooms relatively for long hours [3]. Therefore, it is required to consider the plan to secure the thermal comfort of the living space. This study suggested the quantitative characteristics of the thermal environment of the college town households. The winter season indoor environment was measured and analyzed for 27 one-person households in a college town. Comparison of the data with the suggestions of ASHRAE-55 and ISO 7730[9], the residents, are found to live in a slightly colder environment than the typical comfort zone.

The average room area of the one-person households in the college town was about 30.72 ㎡ (SD 12.77), which was not larger when compared with typical residential buildings in the same region. The awareness of energy cost, however, caused many residents to live in an uncomfortable environment.

Researchers also analyzed the cost required to increase the indoor temperature in consideration of general building information under the assumption of the heating area of 12 ㎡ out of the average indoor area of 30.72 ㎡ of the household samples. The cost required to increase the room temperature by 3℃ was estimated to be about 25.65USD/Month, which is in the PMV level 0-2.

This cost is not significantly higher than the electric cost of 11.12USD/Month incurred when the auxiliary heating device is used to achieve the same temperature. The result shows that residents live in a slightly colder environment than ASHRAE-55 standard when they can acquire comfortable indoor thermal environment with the part-time job of three hours only. A further investigation is required in these aspects.

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