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QUESTIONNAIRE SURVEY OF THERMAL SENSATIONS IN THE LARGE LECTURE ROOM

BADANIA ANKIETOWE WRAŻEŃ CIEPLNYCH W DUŻEJ SALI WYKŁADOWEJ

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Abstract

The article focuses on the subjective assessment of human thermal sensations expressed by them in the questionnaires. The tests were performed in the lecture room of Kielce University of Technology, where 69 students answered the questions about their thermal sensations. The results show that the majority of students felt satisfied and were not interested in changing the conditions. The impact of Body Mass Index revealed itself and was quite obvious.

Keywords: microclimate, thermal sensations, questionnaire survey

Streszczenie

Artykuł koncentruje się na zagadnieniu subiektywnej oceny wrażeń cieplnych ludzi wyrażonych przez nich w kwestionariuszach. Badania prowadzono w dużej sali wykładowej Politechniki Świętokrzyskiej, gdzie 69 studentów odpowiadało na pytania dotyczące ich odczuć termicznych. Wyniki pomiarów pokazują, że większość studentów była usatysfakcjonowana i nie chcieli zmieniać warunków swojego otoczenia. W pracy wyraźnie uwidocznił się również wpływ indeksu BMI respondentów.

Słowa kluczowe: mikroklimat, wrażenia cieplne, badania ankietowe

1. INTRODUCTION

Thermal comfort is of great importance for the health and productivity of building occupants. People spend more and more time indoors, working, studying or resting. Thermal comfort is characterized by the fact that we feel comfortable in given climatic conditions. This means that our body does not feel cold or too warm. Everyone wants to feel comfortable in the room they are in. Undoubtedly, thermal comfort affects the quality of life. Therefore, the aim is to ensure decent thermal comfort conditions through the use of appropriate air-conditioning and heating devices. Failure to provide appropriate conditions will negatively affect our body, productivity and well-being.

Thermal comfort is assessed on the basis of air temperature, relative humidity, average radiation temperature, air velocity and physical activity. In the 1970s, O. Fanger was engaged in research on thermal comfort. Based on extensive literature, Fanger [1] took into account 16 elements that describe the thermal environment and man. For the assessment of thermal comfort, he determined two indicators: PMV

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(Predicted Mean Vote) and PPD (Predicted Percentage of Dissatisfied), which was developed on the basis of ISO 7730 [2] together with PN-EN 16798-1: 2019 [3]. PMV assesses the thermal sensation of room users on a seven-point scale, where –3 means cold and +3 hot. On the other hand, PPD defines the percentage of people dissatisfied with the prevailing conditions in a given room and for class II buildings it is a maximum of 10%. In recent years, research on thermal comfort has increased the interest of researchers. Krakowiak and Krawczyk [4] conducted research on thermal comfort comparing an intelligent building (with air conditioning and heating systems) with a traditional building (without any kind of ventilation). The study was conducted under the same climatic conditions, which showed that students prefer higher air humidity. In the article [5] Dębska and Krakowiak compared three rooms with different methods of ventilation: the first – controlled by the BMS system, the second – without the possibility of changing internal parameters, the third – natural ventilation. The results showed that the best climatic parameters were in the second room. In their study, the authors [6] presented a method of assessing heat and mass transfer along with the related exergies between the human body and the environment. Two women and two men took part in the study and showed that women feel thermal comfort in higher climatic conditions. Also the authors [7] came to similar conclusions that women prefer a warmer environment. Zhang et al. [8] analyzed the influence of walking on thermal comfort in a semi-open space. The study involved 30 people who walked for 20 minutes at different speeds. When people were walking, it was influenced by the speed of air. Subsequent authors, Dębska et al. [9] analyzed an indirect and direct method to assess the thermal sensation of people inside buildings. Research shows that 80% of people did not match the conditions in the room. Jazizadeh et al. [10] reported that the air temperature is the most important factor influencing the thermal comfort of users. The authors [11] analyzed the research on thermal comfort in a single-family house in Poland. Based on 112 questionnaires, it was found that the respondents did not feel well in the room they stayed in. Research has shown that temperature influences the feelings of users. However, men were more satisfied with the prevailing conditions than women. Jindal [12] analyzed the thermal environment and their thermal perception on 130 students. The students felt best in the temperature range from 15.5°C to 33.7°C. The issue of thermal comfort measurements in the intelligent building was considered by Kolkova et al. [13]. The analyses covered two positions of the blinds. It was reported that the optimum temperatures were not exceeded during the study.

This article presents the subjective thermal sensations of students of the Kielce University of Technology, which were compared with the results from the microclimate meter.

2. MATERIAL AND METHOD

The study was conducted in one of the main lecture halls of the Kielce University of Technology, on a group of 69 students (Fig. 1). For this purpose, an environmental meter called BABUC-A, from the Italian company Lsi – Lastem, was used, which recorded all internal parameters, such as: air temperature, black sphere temperature, relative humidity, air velocity, CO_2 concentration. The meter was placed in the center of the lecture hall. The device was in operation for the entire duration of the study.

The second form of research conducted was the use of questionnaire sheets with questions related to the current feelings of people in that room. The participants' task was to assess their thermal sensations, acceptability of temperature, determine their thermal preferences or well-being, along with describing their height, years and weight, which were necessary to calculate the BMI (Body Mass Index). The questionnaire was anonymous and each response had to be marked with a tick in the appropriate box. It was handed over at the beginning of the lecture and the students filled it then, but they also did it after the class. In the present study only the result from the second part were taken into consideration. The questionnaires also contained questions about the clothes, which the students wore. Although they all had various clothing, this fact was not considered in the present study. The clothing insulation varied from person to person, but it was generally similar. Thus, it was omitted in the analysis. Besides, in such a large group the average value of clothing thermal insulation (expressed in "clo") was quite balanced and properly reflected the impact of clothing on thermal sensations.

3. RESULTS AND DISCUSSION

The study was conducted during the summer season in Poland, namely in June, at the large lecture room of Kielce University of Technology and 69 students (21 women and 48 men) filled in the questionnaires with answers about their thermal sensations, preferences and acceptability as well as general sensations. The

Fig. 1. Lecture room where the tests took place

study took part in the afternoon (about 2 p.m.). The participating students were 20-25 years old. Their height was in the range of 150 to 198 cm, while their weight 46-109 kg. Based on these data their BMI values of each person were calculated. During the tests, the microclimate meter provided data on the current indoor air parameters. The measured air temperature was 26.2°C, the mean radiant temperature 23.2°C, relative humidity 53.3% and the carbon dioxide concentration 1223 ppm. The obtained value of temperature indicates that the thermal environment was quite warm. Besides, the level of CO_2 was high, which could have also in some way influenced the answers of the students.

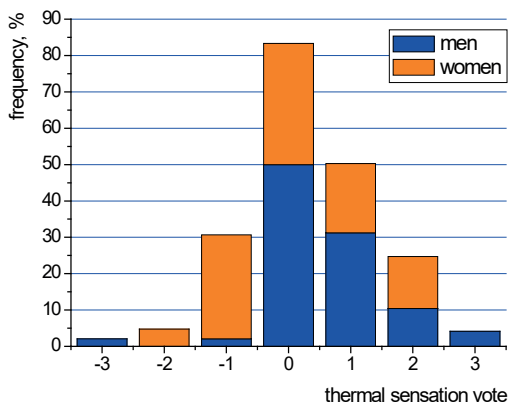

Fig. 2. Thermal sensations of the students in the large lecture room

The question regarding thermal sensations was about how the students rate their current state. They could have selected the following answers: "too hot" (+3), "too warm" (+2), "pleasantly warm" (+1), "neutral" (0), "pleasantly cool" (–1), "too cool" (–2), "too cold" (–3). The results of the investigations have been shown in Figure 2 with the distinction whether the students were female or male.

Based on the questionnaires (Fig. 2) it can be stated that the students in general were pleased with the temperature. Their sensations were mostly neutral (50% of men and over 30% of women) or positive (answers (–1) and (1)). What is interesting is the fact that despite high air temperature, there were still people who experienced cold.

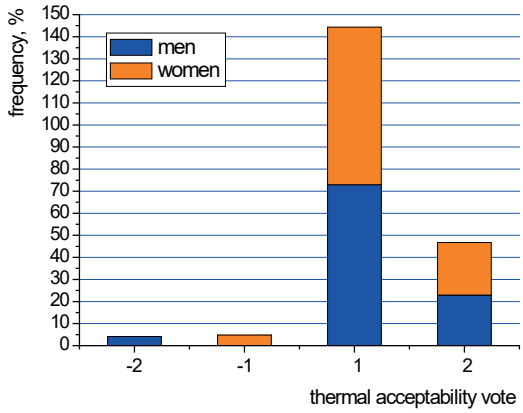

Fig. 3. Thermal acceptability of the students in the large lecture room

The next question was about accepting or rejecting the current conditions. The answers to choose from were: "completely acceptable" (+2), "still acceptable" (+1), "already unacceptable" (–1), "completely unacceptable" (–2). Figure 3 presents the data from the questionnaires.

It seems that almost all the students (despite some negative answers on TSV) found the environment acceptable and highly acceptable. Only marginal votes dealt with the negative sensations. It proves that the students considered the conditions in the large lecture room as pleasent, in spite of the high air temperature of over 26°C. It might be concluded that people in general are fond of warm temperatures, especially when they do a low energy work (in this case: sitting and writing). Probably if the work was harder and required more energy, then the answers could have been different.

The students were also asked about their preferences about the temperature in the lecture theater. Their answers were: "much warmer" (+2), "warmer" (+1), "no change" (0), "cooler" (–1), "much cooler" (–2). Figure 4 presents the test results for women and men separately.

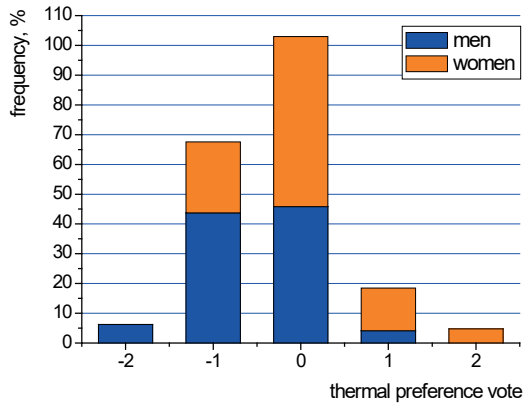

Fig. 4. Thermal preferences of the students in the large lecture room

The largest group of women (over half) and men (almost half) preferred not to change the parameters in the lecture theater. Quite a significant number of people (almost the same as in the case of "0" answer in the case of men) wanted to reduce the temperature. Apart from those the other answers were seldom chosen.

It seems that the students were generally in favour of the thermal conditions, in which they were studying. A proof of it is Figure 5, where the general sensations were presented. The students expressed their opinion as "very good" (+2), "good" (+1), "neutral" (0), "bad" (–1), "very bad" (–2).

Over 40% of women and men expressed they "neutral" voice and about the same number considered the conditions as "good". There were even "very good" answers, but expressed just by some 6% of men. Only ca. 10% of women and 6% of men were not satisfied. As a consequence, it can be stated that the parameters of indoor air were properly selected and led to the positive feelings of the students, despite high air temperature and carbon dioxide concentration.

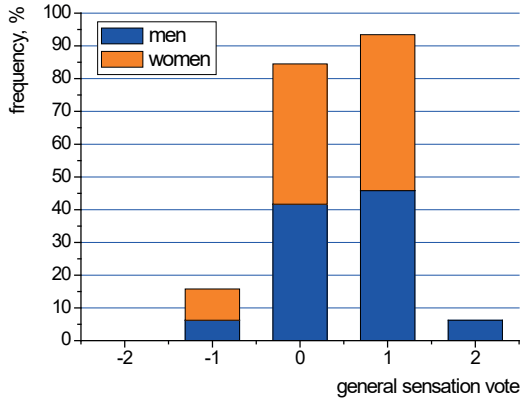

Fig. 5. General sensations of the students in the large lecture room

Another issue in thermal comfort studies is determination of the impact of various factors on human sensations. One of them can be the Body Mass Index. Figure 6 shows the dependency of thermal sensations on BMI.

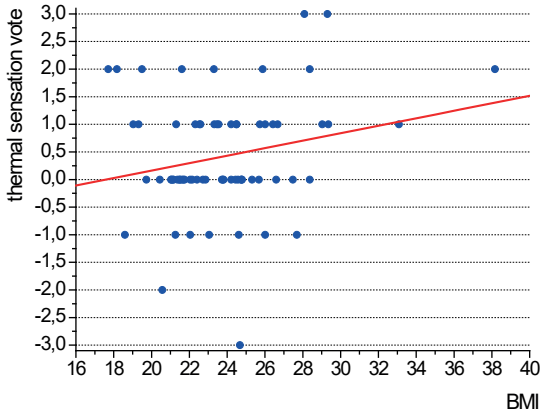

Fig. 6. Thermal sensations vs. Body Mass Index

It seems that as BMI of a person increases, so does their thermal sensations. It seems to be quite natural, but is not considered in the models of thermal comfort, while this impact – judging from the graph – can be significant and might need to be given more attention.

4. CONCLUSIONS

The study covered 69 students situated in the large lecture room of Kielce University of Technology. Their thermal sensations proved that they generally

felt well, despite high air temperature recorded in the room and high concentration of CO_2. There might also be a high influence of BMI on subjective sensations of people, however this might need to be confirmed by larger datasets and extended studies due to the complexity of this issue.

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