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Evaluating the Effects of Individual Characteristics on Thermal Sensation in an Indoor Pool with Different Arrangements for Inlet Air Diffusers

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ABSTRACT: In the indoor swimming pools, due to the presence of people with different individual characteristics, it is important to design an air conditioning system which can provide thermal comfort conditions for the occupants. Since the differences in the persons' individual parameters such as gender and body composition, it is required to study the effect of these parameters on the thermal comfort in swimming pools. On the other hand, the location of the air inlet diffuser is one of the effective factors affecting the thermal comfort conditions. In this study, by using the individual 3-node thermal comfort model, the effect of individual parameters on the thermal sensation of people in an indoor swimming pool has been evaluated. The results show that women are more sensitive than men to the cold conditions. In addition, it can be seen that BMI has a significant impact on people thermal sensation. So, thin people are colder thermal sensation than those with healthy physical fitness, and overweight people have a warmer sensation. Based on the results, with the change in body mass index, the index of the thermal sensation can change up to 0.4 units. This is very important in the evaluation of thermal comfort.

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1- Introduction

Sports facilities, especially indoor swimming pools are one of the spaces with a specific application. Due to high humidity, pollution caused by emissions of chlorine, and also temperature variations; they need air conditioning system with a special design to provide thermal comfort conditions. In 2005, Lee and Hizelberg [1] using the evaporation relation provided by Shah [2] and ASHRAE's handbook of applications [3], simulated evaporation inside a university pool in Denmark. Zolfaghari et al. [4] investigated the interactions between evaporation, thermal sensation, and the concentration of pollutants in an indoor swimming pool using Gagge's two-node model [5]. Another issue that must be considered in the analysis of thermal comfort conditions in the pool is the distinction between the thermal sensation of people with different individual characteristics (such as weight, height, and gender). It should be noted that this issue has not been studied in previous studies. In 2010, Zolfaghari and Maerefat [6] presented a 3-node model based on the heat balance equations that simulated bare skin, clothed skin and core body temperature, separately. Moreover, in 2016, Davoodi et al. [7] developed 3-node model and presented an individual model by considering the personal factors such as gender, age, basal metabolic rate, and body mass index.

In the current study, using the mentioned individual 3-node model [7], the thermal sensation of the swimmers, according to the personal characteristics such as body composition and gender in the simulated thermal conditions in the pool have been studied and analyzed.

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2- Methodology

In the individual 3-node model, the body is divided into three parts including core body, clothed skin, and bare skin. Energy balance equations and thermoregulatory mechanisms have been considered separately for each of these segments. Personal characteristics such as age, weight, height, and gender, which are independent, are given as input to the individualized and developed model. Dependent affecting factors such as body fat percentage, body specific heat capacity, and heat resistance of tissue body are calculated. According to the swimming pool simulation results (temperature and velocity field), the effects of two individual factors of gender and body mass index (BMI) were studied. Results for each gender are presented for three modes of body composition, healthy weight (18.5 <BMI <24.9), thin person (BMI <18.5) and one with overweight (BMI> 30) for the various location of air inlet.

3- Results and Discussion

In Fig. 1, temperature contours for the symmetry plane of the swimming pool has been shown for the case that the air inlet diffuser located at the top of the side wall. Also, Tables 1 and 2 have presented the results for thermal sensation in different conditions for the air inlet located at the top of the side wall of the swimming pool for men and women.

According to the obtained results, women are more sensitive to cold conditions in comparison with men; this is consistent with the results of Lan et al. [8]. The maximum thermal sensation difference is due to gender differences between men and women at the case of air inlet diffusers from the floor, and it is equal to 0.08 units in thermal sensation.

Most variation in the thermal comfort index values in the results are for changes in weight and BMI in people. It can be observed that compared with people with healthy weight, the

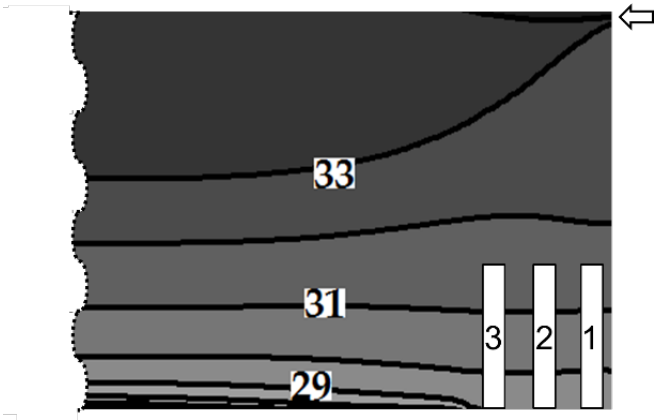

Fig. 1. Temperature contours for the air inlet at the top of the side wall

Table 1. Thermal sensation in different conditions for men

BMI	Thermal Sensation			
	Site 1	Site 2	Site 3	Site 4
healthy weight	-0.37	-0.37	-0.37	-0.39
<18.5	-0.47	-0.47	-0.47	-0.51
>30	-0.24	-0.24	-0.24	-0.24

Table 2. Thermal sensation in different conditions for women

BMI	Thermal Sensation			
	Site 1	Site 2	Site 3	Site 4
healthy weight	-0.4	-0.4	-0.4	-0.43
<18.5	-0.53	-0.53	-0.53	-0.55
>30	-0.29	-0.29	-0.29	-0.31

thinner and fatter people have colder and warmer sensations, respectively. However, based on experimental studies, overweight people show more consistency than thin people when dealing with the cold [9].

4- Conclusions

In this study, using an individual 3-node thermal comfort model, the impact of individual factors on thermal comfort conditions in an indoor swimming pool has been investigated. The study was conducted for 4 different cases of the air inlet diffusers, and the impact of gender and body mass index on perceiving the environmental thermal sensation has been evaluated. After reviewing 96 different cases, the results have shown that the women's thermal sensation is 0.02-0.08 units lower than men's; and thus, they feel the cold more. In addition, the results suggest that body mass index can cause significant changes in the thermal sensation of people, in a way that thin people have the thermal sensation of 0.04-0.15 units lower than a person with a healthy weight. On the other hand, the overweight people have 0.07-0.23 unit higher thermal sensation than those with a healthy weight. This significant difference has shown that they are more compatible with cold in these conditions, and have more neutral thermal sensation compared to healthy people.

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