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Influence of individual factors on thermal satisfaction of the elderly in free running environments

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ABSTRACT

It is important to identify individual factors that influence the thermal satisfaction of the elderly in their homes. This paper presents a field survey and thermal environment investigation in elderly facilities in Shanghai, China. In this study, 17 elderly facilities with 42 free running buildings and 672 healthy elderly people over 70 were randomly selected. Questionnaire surveys and thermal environmental parameter measurements were taken simultaneously. Logistics multiple regression models were established for winter and summer conditions, and influences of individual factors on thermal satisfaction of the elderly in free running environments were analyzed. Results indicated that the factors affecting the thermal satisfaction of the elderly had distinct seasonal differences. 'Satisfaction on wind environment' influenced elderly thermal satisfaction both in winter and summer season. In addition, the influencing factors of the thermal satisfaction also included: "time indoors", "influence of sickness" in winter season and "sleeping regularly" in summer season. Furthermore, the results of this study may be a useful reference when managing or designing thermally comfortable homes for the elderly.

1. Introduction

By the end of 2014, the number of elderly people in Shanghai aged 65 years or above was 2.7 million, accounting for 18.8% of the population [1]. According to the World Health Organization (WHO)'s definition, Shanghai has become an aged society. In accordance with the acceleration of aging process, elderly facilities need to be designed well so they can maintain the health and comfort of the elderly. Occupant satisfaction is an important part of measuring a building's performance [2,3]. The elderly spends more than 80% of their time indoors [4,5], so it is important to identify factors that influence the thermal satisfaction of the elderly in their homes. Previous studies examining the issue of thermal comfort of the elderly in indoor environments were focused mostly on the effects of building characteristics, physical parameters of the environment, such as temperature, humidity, and air speed, etc., and the effects of individual parameters, such as gender, activity and clothing. For example, Mendes et al. [6] found 'Bacteria', 'Fungi', 'Temperature', Relative Humidity', and 'predicted percentage of dissatisfied (PPD) index' are the mostly affected by building characteristics. Yang et al. [7] suggested that satisfaction with indoor environments is related to indoor temperatures in summer and winter; elderly individuals are more sensitive to cold and tend to prefer hot or warm weather. A study by Hwang et al. [8] indicated that gender was not a significant factor in the thermal-comfort requirements of elderly people, while Wong et al. [9] noted that the expected predicted mean vote (PMV) for thermoneutrality conditions of older females was apparently higher than that for older males in the same age group, although the gender differences in the PMV were insignificant from the survey results.

As Fanger [10] said, everyone is not alike, and the comfort equation does not necessarily satisfy everyone. Thus, identical indoor conditions may lead to different subjective responses [11]. Frontczak et al. [11] suggested that not only physical conditions influence satisfaction with indoor environments, and that there may also be other factors, unrelated to environmental quality, such as individual characteristics (occupants' country of origin, level of education, psychosocial atmosphere, time pressure, age, gender, body build, fitness, health, self-estimated environmental sensitivity, etc.), that influence whether indoor environments are considered to be comfortable or not. Similar views were proposed by Ormandy et al. [12], who said that thermal comfort will also depend on the activity and the clothing worn by the individual, and

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the age, health status, gender, and the adaptation to the local environment and climate of the individual and the household; other factors such as household crowding and under-occupation will also have an influence. Yamtraipat et al. [13] also suggested that the state of comfort depends on a wide range of "not quantifiable" factors, such as mental states, habits, and education. Thus, more individual characteristics needed to be identified in order to study how these factors influence the thermal satisfaction of the elderly in a free running environment. Considering the importance of thermal satisfaction to the elderly and the fast-growing number of facilities for elderly people in Shanghai, the influence of individual factors on the thermal satisfaction of the elderly in free running environments needs serious attention. Our study was aimed at identifying these individual factors.

The research plan had three main objectives:

(1) Establish logistic multiple regression models of the indoor thermal satisfaction of the elderly in winter and summer.
(2) Investigate the seasonal differences of individual factors affecting thermal satisfaction of the elderly in free running environments.
(3) Find the main influencing factors affecting indoor thermal satisfaction of the elderly.

2. Methodology

In this study, a field survey was conducted on 672 healthy aged people at 17 elderly facilities in Shanghai, China in order to investigate how different individual factors affected the thermal satisfaction of the elderly. These factors included basic characteristics of each individual (gender, age, education level and profession before retirement), health condition (self-evaluated health state, influence of sickness), living habits (regular exercise, sleeping regularly), acclimatization (time living in local area, time living in elderly facilities, time indoors), self-estimated environmental satisfaction (satisfaction on humidity environment, satisfaction on wind environment). The field study began in January 2014 and was completed in January 2015. Data from elderly facilities were collected mainly in winter and summer; January to March was considered winter while July to August was considered summer. The survey included simultaneous measurement of indoor environmental parameters and gauging of the participants' subjective responses using questionnaires. The surveyors were divided into two groups, with one group measuring parameters and the other administering the questionnaire. The field survey was divided into 3 steps. In Step 1, the participants sit quietly in their room for at least 15 min before receiving their questionnaires. In Step 2, the two groups of investigators entered the room after gaining the agreement of the participants, obtained the basic information on each participant, described the content and aims of investigation to those of the elderly that met the characteristics of the desired sample groups, and invited those elderly people willing to participate in the investigation to sign the informed consent. In Step 3, one of the two groups of surveyors collected data, beginning with explaining to the participants the content of the questionnaires, and then completing the questionnaires through interviews. The other group of surveyors measured the environmental parameters.

Then data were analyzed using SPSS22 statistical analysis software. Logistic regression was used to eliminate the problem that the dependent variable is 0 or 1, that is, to predict the problem of binary classification whose result belongs to 0 or 1. The dependent variable "thermal satisfaction" used in this study is a binary classification variable, "dissatisfaction" or "satisfaction". Therefore, we chose the logistic regression method to analyze the factors influencing indoor thermal satisfaction and binary classification logistics multivariate regression models were established to study the effect of these various factors on the indoor thermal satisfaction of the elderly.

2.1. Sample selection

The field survey took place in Shanghai (east longitude 120° 51′ - 122° 12′, north latitude 30° 40′ to 31° 53′), a city with the highest percentage of aging population in China. Shanghai has a northern subtropical monsoon climate, with four distinct seasons, sufficient sunshine and abundant rainfall. The weather is mild and moist all year. Spring and autumn each usually last only two or three months in a year, while winter and summer are relatively longer. According to China Construction Climate Districts, Shanghai belongs to the hot summer and cold winter district, and can be muggy in summer, and cold and wet in winter.

A total of 17 elderly facilities with 42 buildings were randomly chosen for this research. In most of the facilities, the elderly lived in apartments each of which had a living room and a wash room. Each participant was surveyed in their living room. Up to 97.2% of the rooms had air conditioners (AC), but most of the elderly people did not use these. Therefore, this research only considered the influence of factors for the thermal satisfaction of the elderly people under the condition of free running (FR) environment.

Based on the statistical data through 2012, the average age of people living in elderly care centers in Shanghai was 85.2 years. To guarantee the reliability and representativeness of this research, 672 healthy old people aged 70 and over were randomly chosen from the elderly facilities to participate in the survey. According to the frailty scales developed by Rockwood et al. [14,15], listed in Table 1, this study considered those elderly whose frailty falls between 1 and 4 as healthy people.

2.2. Environmental measurement

The instruments listed in Table 2 were adapted to measure indoor air temperature, relative humidity, air speed and black-bulb temperature during surveys in every room. The evaluation

Table 1
Frailty scale of the elderly.

No.	Frailty scales	Measures
1	Very fit	robust, active, energetic, well-motivated and fit; these people commonly exercise regularly and are in the most fit group for their age
2	Well	without active disease, but less fit than people in category 1
3	Well, with treated comorbid disease	disease symptoms are well controlled compared with those in category 4
4	Apparently vulnerable	although not frankly dependent, these people commonly complain of being "slowed up" or have disease symptoms
5	Mildly frail	with limited dependence on others for instrumental activities of daily living
6	Moderately frail	help is needed with both instrumental and non-instrumental activities of daily living
7	Severely frail	completely dependent on others for the activities of daily living, or terminally ill