The Effects of Indoor Air Velocity on Occupant Thermal Comfort in Winter

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Abstract: In China the thermal comfort standard that regulates the indoor air velocity cannot exceed 0.15m/s in winter. But many scholars doubt this regulation. This paper presents the results of an experimental research project on thermal comfort. The research methods included a questionnaire，physics test, and physiology test. Subjects were tested in indoor natural conditions in winter, through changing the indoor air speed and testing the subjects' body temperature, conduction velocity of the sensory nerve and the conduction speed of the motorial nerve under each condition. The subject's subjective thermal sense and comfort condition were recorded. The longtime blowing effects on the conduction velocity of sensory nerve and the conduction speed of the motorial nerve were considered, and the changes over time of the conduction speed on the nerves were measured. As blowing time increased, the conduction velocity of the sensory nerve and the conduction speed of the motorial nerve both tended to diminish, but the body temperature's change was found to be minimal. As the draft became stronger, the thermal senses changed quickly from neutral to light cool and cool. This experiment also shows that thermal comfort senses can be expressed with the quantification form of the physiology indices.

Key words: thermal comfort, thermal sense vote, air speed, conduction speed of nerves

1 INTRODUCTION

Thermal comfort is defined as the condition of mind that expresses satisfaction with the thermal environment in ASHRAE Standard 55-1992. It is a feel of people in physiology and psychology. Thermal comfort in fact is a series of activities of nerve system to lead a happy feel in psychology [1]. Indoor air speed is an important factor to influence the thermal comfort. It has two main actions on human body, the one is promotes the heat transfer between human body and environment, the other is velocity's increase may produce draft. The two actions jointly affect the feel of thermal comfort and in different seasons, the effects on human body are different. With the change of air speed, human body will make a series of physiological adjustments to adapt the different environmental air speed. These adjustments are the physiological response to the uncomfortableness. So it's necessary to make research on physiological parameters of human body affected by the environmental air speed and thermal sensation. The research colligates the physiological and mental factors and can supply the direct and important indexes for constituting indoor thermal comfort regulations.

2 THE RESPONSE OF ORGANISM TO COOL ENVIRONMENT [2]

In the cool or low temperature environment, though the corporate action of the adjustment organs such as central nervous system autonomic nervous system and endocrine system, make the derma vases shrink, the blood flow of skin decrease and the body surface temperature decline to reduce the body's heat loss. Meanwhile shudder will promote the body's heat production. So the temperature of organism doesn't drop with decline of the environmental temperature. But if organism stays at cool environment too long time or the body's heat production decrease and can't maintain the normal temperature, the body's metabolic rate and oxygen consumption will decline and the function of nervous systems will be in a depressive phase. Finally, organism will behave some defensive response such as hypoesthesia, dysesthesia, disorder of consciousness and so on.

3 THE PHYSIOLOGICAL AND PSYCHOLOGIC INDEXES REFLECTS THE INFLUENCE OF ENVIRONMENT ON HUMAN BODY

3.1 Body Temperature [3]

Temperature is the direct index to judge whether the heat balance is broken or not. The increase of temperature represents the organism's heat production is more than elimination of heat, the heat will accumulate in human body. But temperature's drop expresses the elimination of heat is more than heat production, and then the human body will lose heat. Because of the great regulative capability, except some extreme conditions such as too hot or too cool, the organism heat balance is hard to be broken and the temperature doesn't have big changes. So the condition of organism's heat balance can be judged according to the changes of temperature

$$S = 0.82 \times P \times \Delta T \qquad (1)$$

(1):

S—the heat accumulation or loss in the human body (kcl))

0.82—thermal capacity of organism (kcl / ℃·Kg)

P——human body weight (Kg)

3.2 The nerve Systems [4]

In all the organs of human body, nerve systems are the fastest reactive to environment. Sense nerve system is the tool that codes and transfers the information from other cells or environment. Motor nerve system is the special nerve system to execute motor. For example: the temperature sense receives the information form environmental temperature and transfers them to cerebra. At last make organism have sense of coldness or hotness. With the cooperation of senses of coldness and pressure, human body can have the feel of moisture. Nerve systems are the main physiological systems to receive and handle thermal information from environment. They have direct connection with operational capability and efficiency. Generally use the nerve conduction speed to indicate the performance of nerve systems

3.3 Thermal Senses [5]

Human body's thermal influence or thermal senses or thermal efficacy or thermal load caused by environment belong to subjective feel. How to express these feels is an important problem in the research on thermal environment. To quantify these subjective feels, majority scholars adopt the seven levels grading method. That is grading thermal senses as seven levels: hot, warm, light warm, neutral, light cool, cool, cold

4 RESEARCH METHODS

Twenty students (ten boys and ten girls) were invited as subjects to participate in the experiment. The subjective questionnaire and objective field testing methods are conducted. Multivariate and multilevel are concerned to exam the changes and trends of physiological parameters affected by the air speed. The questionnaires of were investigated and in the meantime the indoor thermal parameters were recorded

5 CONTENTS OF THE EXPERIMENT

(1) Layout of the measuring points

In order to obtain temperature in the test room, thermocouple measuring points were set in three positions, which are 0.1m, 1m, and 1.5m from the floor (as subjects' foot ankle, abdomen and neck). Fig.1 is the schematic map of whole arrangement of experiment plat and thermocouple measuring points.

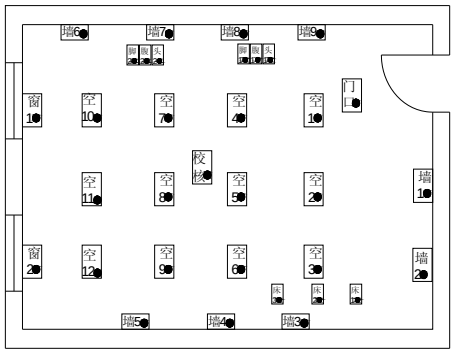


Fig. 1 Site layout of experiment in the test room

(2) Questionnaires

The questionnaires include the subject's background data and the vote for thermal senses.

(3) The test of the physiological parameters

The main test parameters include: the mouth temperature, the sensory nerve conduction speed (SCS), motor nerve conduction speed (MCS). Use mercury

thermometer whose ratio precision is 0.1℃ to test mouth temperature. The apparatus tested the nerves conduction speeds is the photoelectricity / myoelectricity /evoked potential detective apparatus made in Japan. It's maximal irritative current flow is 100mA, frequency sampling is 50 Hz and the maximal sampling time is 10 minutes.

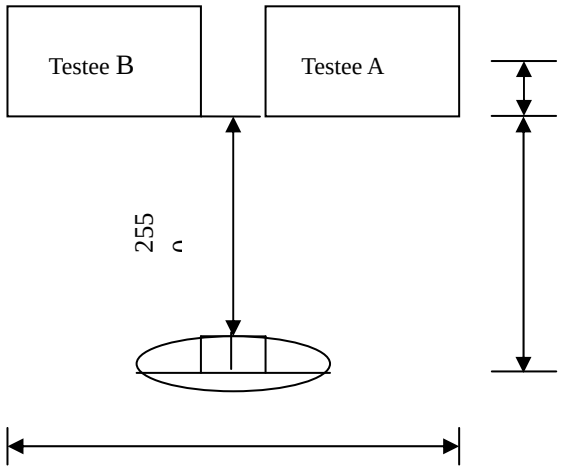
6 PLAN OF THE EXPERIMENT

In this experiment, we classify thermal environment as two conditions: condition 1 the air speed in the test room is about 0.2m/s; condition 2 the air speed in the test room is about 0.5m/s.

Table 1 the thermal environment parameters

Condition	Indoor environment Temperature	Indoor air speed	Outside temperature
1	12.7	0.19m/s	9.9
2	13.1	0.49m/s	10.0

At the control of the air speed, we chose the floor fan as the wind regime. The wind blows windward. The position map of the wind regimen and subjects as follow:



The experiment flow of condition 2 is as same as condition 1.The experimental flow as follow:

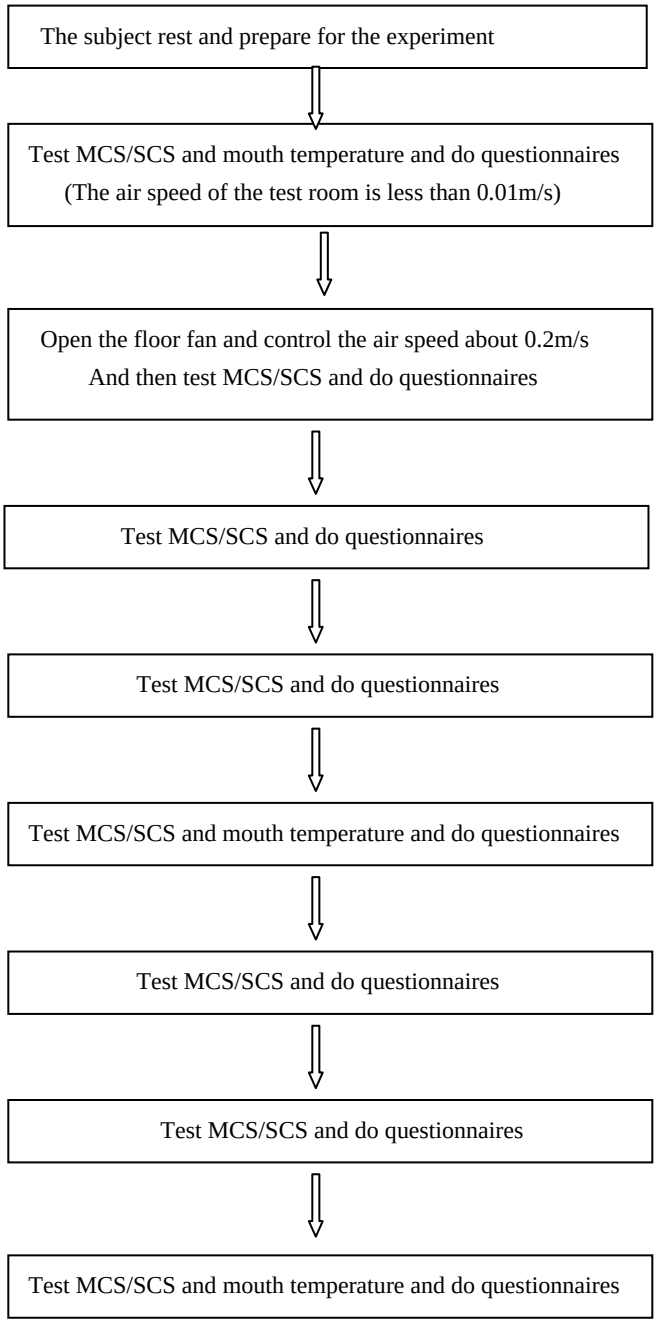


Table 2 the time chart of sampling time

Test / Time / Parameter of test	Working Condition： Little wind、Hard wind (min)								
MCS	No wind	5	10	15	20	30	40	50	60
SCS	No wind	5	10	15	20	30	40	50	60
Body tempe-tature	No wind					30			60
questionary	No wind	5	10	15	20		40		60

7 ANALYSIS AND CONCLUSION

7.1 The motor Nerve Conduction Speed (MSC)

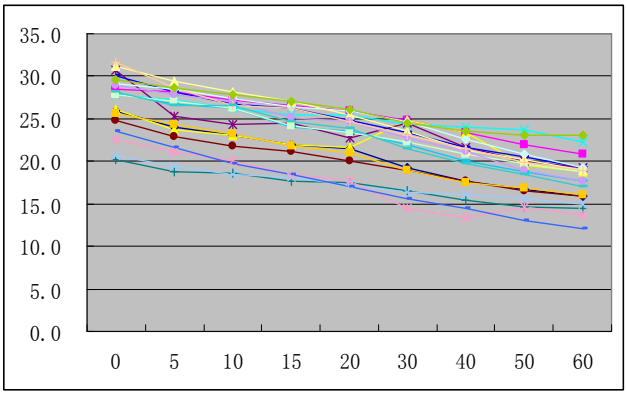


Fig.2 the change of MSC with blowing time in condition 1

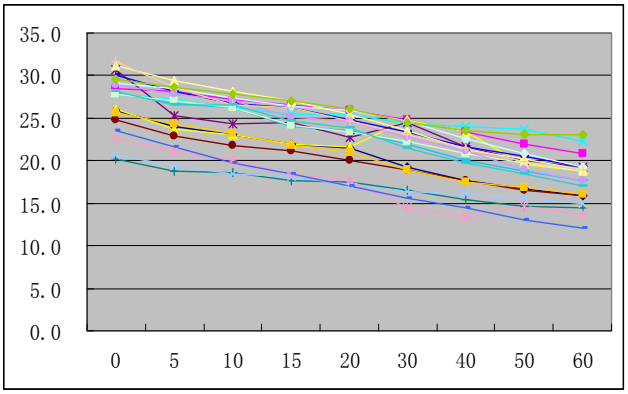


Fig.3 the change of MSC with blowing time in condition 2

From figure 2 and 3, we can see that in the conditions1 and 2, the MSC of the subjects declines with the blowing time's increase. In the condition 1 that is the indoor air speed is small, during 0-10 minutes, the change of motor nerve conduction speed is light fast; during 10-20 minutes, the MSC change light slowly; during 20-60 minutes the change of MSC accelerates, but the change rate is still smaller than that in 0-10 minutes. In the condition 2 that is the indoor air speed is big, during 0-20minitues, the MSC changes light fast, compared with the condition 1, the time span of this stage in which MSC changes light fast increases by 10 minutes; during 20-60minutes, the change of MSC is light slow, compared with condition 1, there is no the stage in which the MSC change slowly. Compared with the change range of MSC we find that continuous air flow has great impact on MSC. The air speed is more bigger, the change of MSC is also more bigger.

7.2 The Sense Nerve Conduction (SCS)

According to figure 4and 5, we can get that affected by the continuous air flow the SCS declines with the increase of the blowing time. In condition 1, during 0-10minutes, the SCS changes light fast; 10-15 minutes is the stage in which the SCS change slowly; after that, during 15-60 minutes, the change of SCS becomes fast but is still less than that during the first ten minutes. In condition 2, during 0-10 minutes, the SCS changes light fast; after that the SCS changes light slowly. And the stage in which the SCS change slowly doesn't appear. The change trends are like the MSC's in the same condition. In the two conditions, the change

range of the SCS is same. According to this, we can include: the continuous air flow has big effect on the SCS but there are nearly no differences between the change ranges of SCS affected by different air speeds.

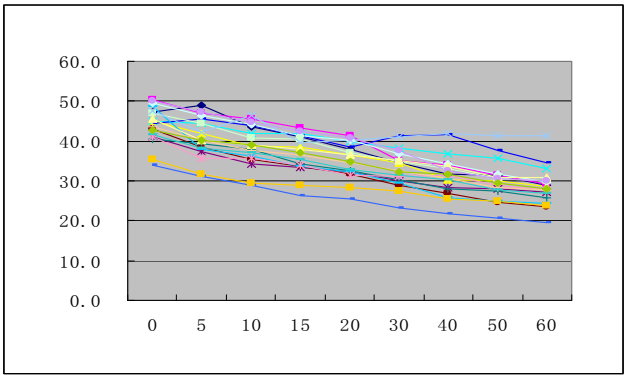


Fig. 4 the change of SCS with blowing time in condition 1

7.3 Temperature

Compared with the temperatures of the two conditions, we find that the changes of temperatures with the change of blow time and air speeds are not obvious. There are nearly on changes. This indicates the air speed is of small influence on temperature.

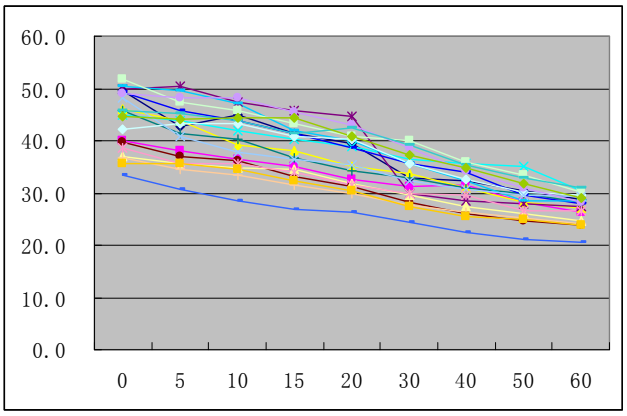


Fig.5 the change of SCS with blowing time in condition 2

7.4 Thermal Senses

In the two conditions, the change trends of all the subjects are obvious. Blowing ten minutes, thermal senses of majority subjects becomes from light cool, light warm to light cool, cool, cold. After 40 minutes, almost all the subjects' thermal senses became cool or cold and had strong feel of draft. The anticipative phenomena that the change rate of thermal senses would have close connection with the value of air speed didn't appear. The continuous air flow has obvious influence on the change of thermal senses, but there are no obvious differences between the influences of different air speeds on the change rate of thermal senses.

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