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THE INFLUENCE OF AIR TEMPERATURE ON THE PERCEPTION OF BODY ODOR

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Ambient temperature may influence both the emission and the perception of human odor. This paper studies how human odor is perceived at different temperatures. The intensity of human odor in an auditorium was judged by an odor panel in an adjacent space. The ventilation rate of the occupied auditorium was 5-17 L/sec • person. A continuous sample of odorous air was exhausted from the auditorium through a glass tube to an odor test station. One-half of the air flow was heated 1-7 K, and the other half was unheated. The odor panel was asked to compare the odor intensity of the two air flows. The air flow judged to have the strongest odor was stepwise diluted with clean air (air temperature difference maintained). The dilution required to provide the same odor intensity in the two air flows was estimated. At air temperatures 23-32 °C no significant influence of temperature on perceived intensity of body odor was found. The ventilation requirement in auditoria and similar spaces is likely to be independent of the temperature level, provided that the occupants are kept thermally neutral or cooler, so that little or no perspiration occurs.

Introduction

The aim of the present paper is to study the effect of air temperature on the perception of body odor. In spaces with high occupancy, such as auditoria, theaters, and classrooms, body odor is the contaminant which most usually determines the required ventilation.

Air temperature may influence the required ventilation in two ways: by changed odor emission or by changed odor perception. The odor emitted from the occupants may increase at higher ambient temperatures when perspiration occurs (Lehmberg *et al.*, 1935). However, lighter clothing may compensate for a higher temperature, and air temperature alone is therefore insufficient to predict perspiration secretion and odor emission. Odor emission and the corresponding required ventilation should be studied as a function of both temperature and clothing.

At a constant body odor emission, the odor intensity in a space may still be perceived as stronger or weaker at different air temperatures. The present study has investigated whether such a temperature influence exists. This paper is the first result of a larger study to identify odor intensity as a function of temperature, ventilation rate, and space volume per occupant. The entire study is based on a new method for comparing odors.

Facilities

An odor test station was placed between two auditoria at the Technical University of Denmark. The principle in the new testing method involves people on an odor panel who compare two air flows with different odor intensity and dilute the strongest odor until the two odors are equal. In this way, the relative effect of space volume per occupant and of temperature on ventilation requirements can be studied.

In the present part of the odor investigation, only odor from one auditorium was studied. The odor was emitted from students attending normal lessons in an auditorium that seats 172 persons and has an air volume of 850 m^3. No smoking was permitted. The auditorium was mechanically ventilated; the air change could be maintained at any desired level up to 5.5 h^{-1}. The outdoor air was filtered, and could be heated but not cooled, humidified, or recirculated. The air change was measured by a tracer gas method.

An odor test station was placed in the test room adjacent to the auditorium (see Fig. 1). The test room was ventilated with outdoor air to ensure that the odor intensity was negligible compared to the intensity in the auditorium. The volume of the test room was 320 m^3 and the air change was 1.3 h^{-1}.

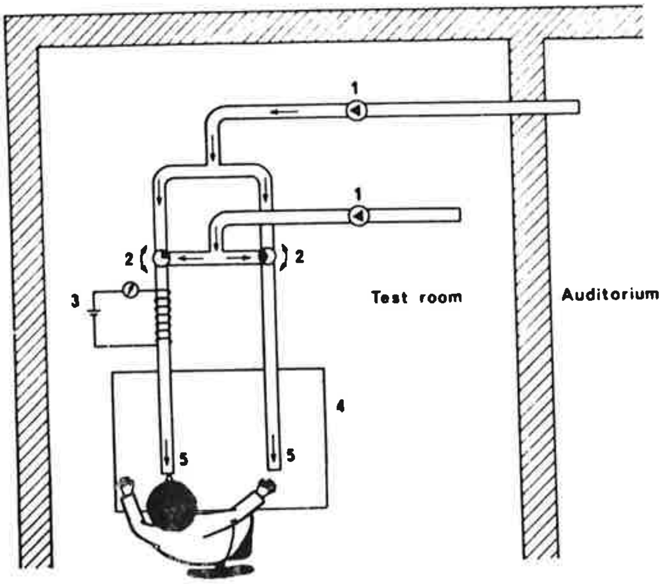

Fig. 1. Odor test station: (1) fans; (2) dilution valves; (3) electrical heating; (4) exhaust cabin; (5) outlets for odorous air.

A continuous sample of odorous air was exhausted from the auditorium to the odor test station, as shown in Fig. 1. At the odor test station the air flow was split into two identical pipe systems, each with a dilution valve. In the valves the odorous air could be diluted with "fresh" air from the test room. The air in one pipe was electrically heated to a temperature from 1 to 7 K higher than the air in the other pipe. Undiluted, the two air flows had the same composition. The panelist was instructed to compare the odor intensity of the heated and unheated air and to judge which of them was perceived as the strongest. The diameter of the pipe was 50 mm, the air velocity in all experiments was maintained constant equal to 0.5 m/sec at the outlet, and the transport time from auditorium to panelist was 7–10 sec.

The transport system for the odorous air consisted of pipes, packings, fans, and dilution valves. Preinvestigations were performed to identify, for the odor transport system, materials having a negligible effect on the odor level of the transported air. Glass (for the pipes) and teflon were selected as the most suitable materials. Even with these materials there was a slight but perceivable emission of odors from the materials to the air. This emission was equal for both air flows being compared and therefore of minor importance.

In the dilution valves developed at the laboratory and constructed of teflon it was possible to dilute the odorous air in eight steps with the following dilutions: 100% (i.e., pure dilution air), 86%, 69%, 49%, 33%, 19%, 10%, and 0% (i.e., undiluted air). The position of the valve did not change the total flow rate in the two air flows being compared.

Odor Measurements

The odor panel consisted of five subjects. All were male students and nonsmokers. Prior to the experiments, they were exposed to "The Intensity Rating Test" with amyl acetate in propylene (ASTM, 1968). None of the panelists suffered from anosmia.

The odor measurements were taken during normal lessons, the duration of which was 80 min with a 10-min break after 35 min. During each lesson the auditorium was ventilated with outdoor air at a rate predicted from Yaglou's diagrams (Yaglou *et al.*, 1936) to cause an odor intensity around 2 on Yaglou's psychophysical scale (0:None, ½:Threshold, 1:Definite, 2:Moderate, 3:Strong, 4:Very strong, 5:Overpowering).

Experimental conditions are shown in Table 1. In the odor test room the air temperature was 22–24 °C and the relative humidity 30%–40%. The temperature of the air flow at the outlet of the unheated pipe was, due to heat transmission from the odor test room, approximately the same as the air temperature in this room.

The members of the panel were called to the test station one at a time for odor judgements. Each panelist was asked to compare each of the following seven dif-

Table 1. Experimental conditions.

Lesson Number	1	2	3	4	5	6	7	8	9	10
Temperature difference between heated and unheated air (K)	1	1	1.5	1.5	2	2	3	3	7	7
Temperature of unheated air (°C)	24.2	23.6	22.8	23.3	24.7	25.1	22.8	23.3	22.5	25.0
Air temperature in auditorium (°C)	26.6	23.0	22.5	23.1	26.6	26.2	24.6	23.8	23.8	26.0
Relative humidity in auditorium (%)	45	57	48	48	47	45	34	49	34	38
Number of occupants	126	110	90	83	88	83	90	69	86	70
Space volume per occupant (m^3/p)	6.9	8.0	9.7	10.5	9.9	10.5	9.7	12.7	10.2	12.5
Ventilation rate (L/sec • person)	5.5	5.2	8.7	17.3	7.6	6.0	7.2	9.3	7.5	4.5
Odor intensity predicted from Yaglou's diagrams	2.2	2.1	1.6	1.2	1.7	1.8	1.7	1.4	1.7	1.9
Number of odor tests	9	10	11	11	12	11	12	10	4	5

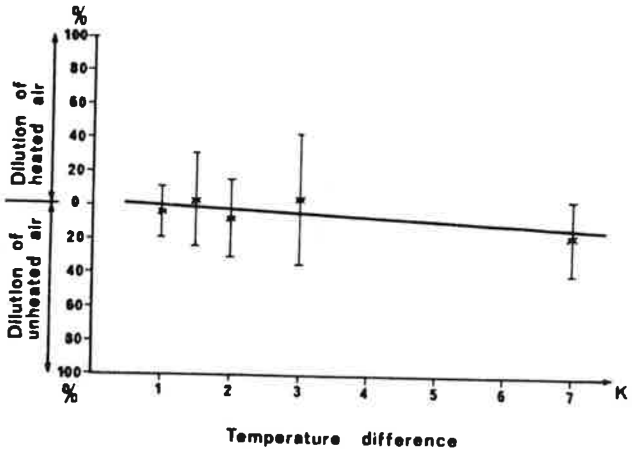

Fig. 2. The influence of increased air temperature on the dilution required to maintain the same perceived odor intensity of heated and unheated air. Standard deviations and the regression line are shown.

ferent combinations of odorous air: both air flows undiluted, or one of the two samples diluted with 19%, 49%, or 86% dilution air, while the other sample was undiluted. These seven combinations were presented in a random order.

During each lesson the temperature difference between the air in the two pipes was kept constant at 1, 1.5, 2, 3, or 7 K (Table 1).

Each panelist was instructed to compare the two air flows and to judge which of them he perceived as having the highest odor intensity. For each test the dilution required to obtain the same perceived odor intensity of the two air flows was then estimated.

Exposure time was 20 sec and regeneration time at least 20 sec. The total duration of each test was 5–7 min. The number of tests in each lesson is given in Table 1.

Results

The mean value of the dilution required to maintain the same perceived odor intensity of heated and unheated air at five different temperature differences is plotted in Fig. 2. The regression line has a slope not significantly different from zero.

The odor intensity increased during each lesson, mostly during the first lesson in the morning. To study whether the temperature influence on odor perception was different at different odor levels, two periods were compared: the first and the second half of the first lesson on the test days. No significant difference was found between the required dilution in the two periods with different odor intensity.

Discussion

For air temperatures 23–32 °C this study showed no significant influence of temperature on the perception of body odor. This indicates that the ventilation requirement will be the same in spaces with different temperatures provided that the body odor emission is the same. This is likely to be the case when little or no perspiration occurs, i.e., when sedentary occupants feel thermally neutral or cooler. Typically, this may occur for occupants in winter indoor clothing (1 clo) below 23 °C or in summer clothing (0.5 clo) below 26 °C.

A methodological problem appeared in some cases when the temperature difference was highest. In some cases panelists expressed difficulties in comparing odor intensities of air of such differing temperatures. Disregarding the results at the highest temperature difference, however, would not change the conclusion (see Fig. 2).

Conclusion

At air temperatures 23–32 °C no significant influence of temperature on perceived intensity of body odor was found.

The ventilation requirement in auditoria, theaters, and so on, is likely to be independent of the temperature level provided that the occupants are kept thermally neutral or cooler, so that little or no perspiration occurs.

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