MECHANICAL VENTILATION IN AN OFFICE BUILDING AND SICK BUIDING SYNDROME. A SHORT-TERM TRIAL.

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Abstract

The effects of mechanical ventilation on the sick building syndrome were evaluated in an office building with 2150 employees. The ventilation rate was known to be high in the building. The main hypothesis put forward was that reducing the rate of mechanical ventilation would alleviate symptoms. A short-term trial was carried out by shutting off the ventilation in one part of the building, reducing it in two areas and leaving one part unaltered as a control. The reduction of ventilation had if any, an opposite effect that was anticipated. There was a linear correlation between increase in symptoms and rise in room temperature to above 22°C.

Introduction

In a substantial number of large modern buildings, office personnel have often complained of a similar set of symptoms, known as the sick building syndrome (SBS) (4). Synonymes of the SBS are: building illness syndrome, building-related illness, ill buildings, stuffy offices and tight office building syndrome (1). Typically, the cause of the symptoms has not been found in spite of thorough investigations.

In two non-experimental British studies prevalences of symptoms in naturally ventilated, mechanically ventilated and fully air conditioned buildings were compared. Finnegan et al. found singnificant excess of nasal, eye and mucous membrane symptoms with lethargy, dry skin and headache in mechanically ventilated and air conditioned buildings and suggested that these six symptoms represent the sick building syndrome (2). Robertson et al. compared the symptoms of employees in a naturally ventilated and a fully air conditioned office building. In this study the employees in the air conditioned building had significantly more "dry" symptoms (stuffy nose, dry throat, dry skin), allergic symptoms (blocked, runny or itchy nose, watering or itching of eyes), lethargy and headache, which were called "building sickness" (3). Environmental measurements were made in all the rooms, no differences between buildings were found. Both studies concluded that the excess of symptoms was related to the ventilation system.

We studied the SBS symptoms in relation to mechanical ventilation in a modern 8-floor office building, with 2150 employees. The building is fitted with mechanical ventilation mainly without recirculation and humidification. The employees exhibited symptoms typical of the SBS described in other studies. The ventilation rates were known to be high. The main hypothesis, which was based on the study of Finnegan et al., was that reducing the rate of mechanical ventilation would alleviate symptoms.

Materials and methods

Baseline data of air handling and heating systems were collected and measurements of airflow, temperature and relative humidity in office rooms were made in February 1985. A questionnaire was sent to each employee, inquiring about symptoms, diseases, complaints, attitudes towards working conditions, details of home and working environments and health behaviour. Air velocities, exposure concentrations of chemical and biological factors, particles, ions and radon were also measured during the study.

Following the baseline data collection a short-term trial was carried out by shutting off the ventilation in one part of the building, reducing it in two areas to 40 and 25% of the original rate, and leaving one part unaltered as a control. Personnel on floors 3 - 8 were selected for thorough analysis since the mostly clerical work was similar and it was possible to form areas wih identical working conditions and ventilation. The personnel were informed that adjustments will be made to the ventilation but the degree of alteration was not revealed. Two follow-up questionnaires were sent out in March - April, concentrating on symptoms and complaints both 3 days and 3 weeks after the change in ventilation rate.

The analysis was carried out in two parts. One consisted of the analysis of trial data relating to personnel who returned all questionnaires (n = 940) and other cross-sectional analysis of the baseline data on one person from each room (n = 968). The response rates in the first (81%), second (70%) and third inquiries (71%) were good. A summation score (range 0 - 6) was calculated, describing the total amount of SBS symptoms including nasal, eye and mucous membrane symptoms, lethargy, skin symptoms and headache.

The effect of changing the ventilation rate was estimated by evaluating individual differences in the summation score between the baseline questionnaire and the two follow-up questionnaires in different areas of the building. Confounding factors based on individual differences among personnel could thus be controlled. In the analysis of covariance confounding factors based on group differences were also controlled.

Results

Indoor air quality

The concentrations of measured indoor air pollutants were far below the recommended values. The relative humidity was very low in February (10-15%) and low in March - April (20-25%). There was a great variation in ventilation rates (10-70 L/s/person) in the building, but all values exceeded the minimum requirements. Also the variation of the room temperature (21-26°C) was large and the average temperature was high (23.3°C).

Health survey

The 7 day prevalence of symptoms at work among all personnel (n = 1719) was large in February: about half the subjects experienced dryness of skin (55%), nose (51%) and throat (43%) and nasal congestion (51%) and about one third complained of itchy skin (32%), headache (33%) and lethargy (33%) and one fifth of irritated (22%), itchy (24%) or dry eyes (18%).

Trial. In general the occurrence of symptoms decreased between February and March - April. No immediate effects due to the change in ventilation were observed. In three weeks the occurrence of symptoms decreased less in the area where the ventilation was reduced (Table 1.).

Table 1. The average change of the SBS-score in different areas of the building between the baseline inquiry and the inquiry three weeks after the change in the ventilation. The averages are adjusted by sex and baseline value of SBS-score.

Proportion of the original ventilation rate after the change	n	Average change of the SBS-score	
		Average change	Difference to the control
Control	487	-0.40	
40%	122	-0.23	+0.17
25%	104	-0.30	+0.10
No mechanical ventilation	189	-0.18	+0.22

Analysis of covariance: control vs. others $p < 0.05$

The difference was small but statistically significant. Thus the reduction of ventilation rate had an opposite effect to that anticipated. Awareness of the change in ventilation did not eliminate the change in the symptoms.

Cross-sectional analysis. In the cross-sectional analysis of baseline data the room temperature was the most important indoor air factor determining the SBS symptoms. Average summation scores of employees in four room temperature groups were compared, adjusting the symptoms scores for influences of sex, atopic tendency, passive smoking and attitude towards the social atmosphere by the analysis of covariance. As shown in the table the SBS-score increases monotonously with increase in temperature both for symptoms experienced mostly at work as well as equally at work and at home (Table 2.).

Table 2. Adjusted summation score of SBS symptoms in workers by the room temperature. Seven day period prevalence of symptoms experienced equally at home and work and mostly at work.

Room temperature (°C)	n	SBS-score (range (0-6)	
		Symptoms experienced equally at home and at work	Symptoms experienced mostly at work
≤ 22	30	2.1	0.9
$> 22 \leq 23$	102	2.5	1.3
$> 23 \leq 24$	135	2.8	1.4
> 24	50	3.0	2.0
Linear trend by regression		$p < 0.05$	$p < 0.05$

Also the sensation of dryness increased by the increase in temperature.

Discussion

We conclude that mechanical ventilation as such does not cause symptoms. In the previous comparisons of employees in buildings with different ventilation systems, the ventilation system was apparently not the only relevant difference between the working environments. Mechanical ventilation probably indicates a certain type of building and HVAC technology, which includes many risk factors of symptoms and complaints. In buildings fitted with mechanical ventilation, low ventilation rates may cause health problems and complaints.

Due to cold weather in Helsinki, the relative humidity indoors was very low, which possibly intensified the effect of temperature on the SBS symptoms and the sensation of dryness.

In studies of the association of symptoms and complaints with indoor air quality, many possible confounding factors must be taken into account. Age, sex and atopic tendency may affect the experience and expression of symptoms. A large number of psychosocial factors may also affect the occurrence of symptoms and complaints. In this study the attitude towards the social atmosphere at work was found to affect the occurrence of symptoms. Thus the study design is often crucial in controlling the confounding.

References

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MONITORING OF SYMPTOMS AS A CONTROL OF THE EFFECT OF INTERVENTION IN THE SICK BUILDING SYNDROME

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Abstract

Employees in seven different buildings were asked to fill in a simple questionnaire at the time where a sick building syndrome was diagnosed in the buildings. After changes and alterations in the buildings were carried out the employees were asked about indoor climate symptoms after a one year period of observation.

Results. Reduction of symptom frequency was observed in some buildings, however in other buildings no positive effects were observed at all. Consequently proposed changes in buildings are not always relevant. This result indicates that systematic monitoring of employees symptoms before and after introducing building changes should be routinely carried out when tackling indoor climate problems.

Introduction

The 'sick' building syndrome (SBS) is characterized by persons staying in a building having an extra frequency of symptoms. By medical examination there is often few or no abnormalities.

Various exposures have been related to the SBS, but measurements of the exposures are in many cases of little usefulness.

As recommended by Akimenko et al (1) there is a need for follow-up studies used by architects, engineers and authorities on cases where major changes is planned in the buildings. These follow-up studies are recommended to include a health surveillance.

When a SBS has been diagnosed the only way to prove that the changes are relevant is the registration of a decline in the symptoms of the persons after intervention.

The aim of the study was to evaluate if changes in the building had an effect on the symptoms of the persons suffering from SBS.

Material and method

The following demands to the method were set up:

1. the method should be simple and prospective
2. Engineers, local authorities, occupational health services should be able to use the method as a routine in controlling the effects of changes
3. the persons suffering from SBS should be their own control
4. data should be quantified
5. a "healthy workers effect" should be evaluated
6. information-bias/placebo-effect should be diminished or evaluated

The design of the study was: