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Health, Energy and Thermal Comfort

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Abstract

This study examined the impact of providing thermal control systems on occupants' wellbeing in two particular European contexts, including a Norwegian cellular plan office with high levels of thermal control and a British open plan office with limited thermal control. The former provided each occupant with a personal office, within which openable windows, blinds, door and the ability to control the temperature was provided. In the Norwegian approach, personal differences in perceiving the thermal environment were respected and the architectural design of the building allowed each individual to set the thermal environment. In contrast, limited openable windows were provided for occupants seated around the perimeter of the building in the open plan office. The main strategy in the British approach was to provide a uniform thermal environment for all occupants according to the standard comfort zone. Natural ventilation was the main system, while in the Norwegian practice a combination of natural ventilation and air conditioning was in operation. As a result, the energy use of the Norwegian practice was much higher than the British practice. A field study of thermal comfort was applied with a particular emphasis on grounded theory. Survey questionnaires, environmental measurements and interviews were conducted. The Norwegian occupants reported much higher health rate up to 40% compared to those in the British practice. The follow up interviews revealed the importance of lack of thermal control on occupants' wellbeing. A balanced appraisal was made of energy performance and users' health between the two buildings.

Keywords Sick Building Syndrome; Thermal comfort; Individual control; Energy; Workplace.

1. INTRODUCTION

Currently, over 80% of people's time is spent indoors [1], which makes their health dependant on the quality of the indoor environment [**Error! Reference source not found.**]. In the 1980s, after air conditioning was practiced in the workplace, ill health reports increased [2], which provided the ground for arguments as whether air conditioning is responsible for building related symptoms. Recently, natural ventilation is encouraged in the building industry to reduce the energy consumption and greenhouse gas emissions. Natural ventilation is discussed as the perfect key to resolve energy, economic and environmental challenges. There is a risk of prejudgement to consider it to improve occupants' health. Occupants' wellbeing in naturally and mechanically ventilated buildings were compared [4] although contradictory outcomes were reported [5]. Other factors, such as thermal control, were not considered in these studies. This study examined the impact of providing thermal control in the workplace on occupants' health. Occupant wellbeing was compared in two contexts with high and low levels of providing thermal control systems for individuals: Norwegian cellular and British open plan office, respectively. Air conditioning was operating in the Norwegian practice, while natural ventilation in the British office. Energy and building performance as well as users' wellbeing were compared in these two contexts.

2. METHODOLOGY

A field study of thermal comfort was applied with a particular emphasis on grounded theory to compare the two buildings in summer 2012. 167 respondents with sedentary activities participated in the research. Their health condition was surveyed regarding eyes, nose, chest, throat, headaches and tiredness. Environmental measurements were applied and the dry bulb temperature, relative humidity, and mean radiant temperature were recorded.

3. ANALYSIS

In the cellular plan office, air conditioning was working and each occupant was provided with access to an openable window, blinds, door and the ability to adjust the cooling or heating. In the open plan office, openable windows were provided for limited occupants seated around the perimeter of the building and the majority of the occupants had no access to any means of thermal control, as presented in Figure 1.

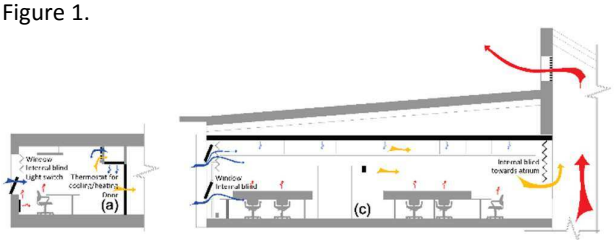

Figure 1. Sections of environmental control and summer day ventilation systems: (a): Norwegian cellular plan office and (c): British open plan office

The energy consumption of the buildings was compared against the CIBSE benchmark. The British practice had a low energy consumption (150 Kwh/m2 year) within the acceptable range. In contrast, the Norwegian practice had a high energy usage (1550 Kwh/m2 year), which exceeded the limit, presented in Figure 2.

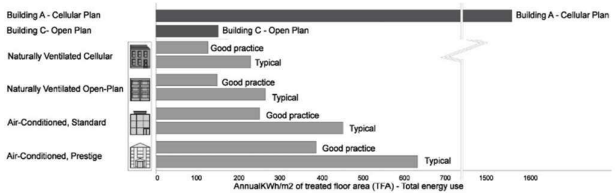

Figure 2. Energy consumption of the buildings and CIBCE benchmark KWh/m2 year [**Error! Reference source not found.**]

Regarding health, quantitative analysis using the SPSS linear regression was applied, as presented in Table 1. The results indicated a significant relationship between the symptoms and the type of plan, except blocked or runny nose symptom.

Table 1. Linear regression analysis of the symptoms and type of plan

	P values		
Eyes	0.030	<0.05	A significant relationship
Nose	0.663	>0.05	No significant relationship
Throat	0.001	<0.05	A significant relationship
Headaches	0.000	<0.05	A significant relationship
Tiredness	0.000	<0.05	A significant relationship
Overall health	0.000	<0.05	A significant relationship

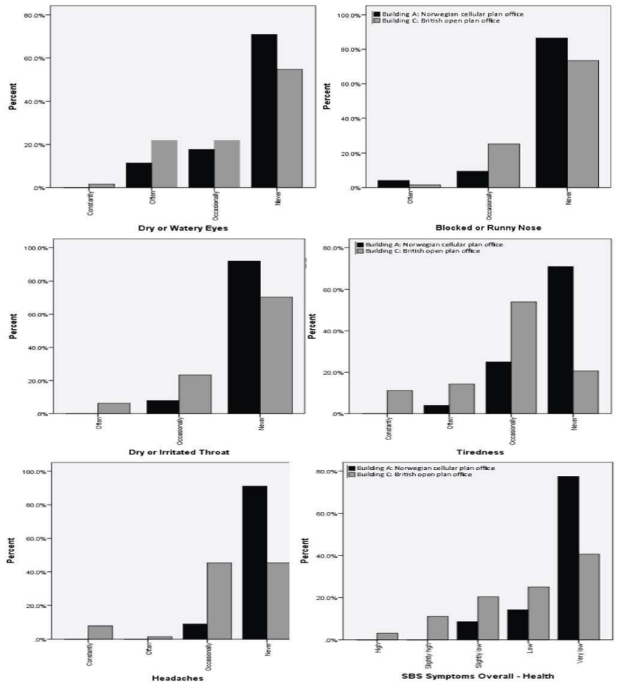

Figure 3. Comparing the SBS symptoms in the open and cellular plan offices

Figure 3 demonstrates the comparison of the symptoms in the British and Norwegian practices. The frequency of the symptoms was higher in the British office, particularly in headaches, tiredness and the overall SBS symptoms. 80% of the occupants of the Norwegian office reported suffering from no symptoms, while only 40% in the British office, as presented in Figure 3. Overall, the Norwegian occupants suffered 40% less than British occupants. The follow up interviews confirmed that lack of availability of thermal control influenced users' health in the open plan office and the availability of thermal control was appreciated in the cellular plan office.

4. Discussion and Conclusion

The results of the building related symptoms showed that occupants of the naturally ventilated British open plan office suffered 40% more than the occupants of the air conditioned Norwegian cellular plan office. The regression analysis showed a significant relationship between the type of plan and frequency of the symptoms, while no significant relationship was found between the symptoms and carbon dioxide level. The results also suggested a significant relationship between the symptoms and thermal environment as well as the availability of thermal control systems for occupants, which was much higher in the air conditioned office compared to the naturally ventilated office. This questions other research in the field that identified air conditioning as the main cause of building related symptoms [4,6,8,**Error! Reference source not found.**]. Currently, low carbon and energy efficient strategies are encouraged. However, this study suggests that the availability of the ventilation system, thermal control systems and the design of the workplace significantly influence the building related symptoms. Norwegian personal offices with high levels of thermal control provided a healthier work environment compared to the energy efficient British open plan offices with limited environmental control. The study suggests a balance between providing thermal control and energy efficiency.

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