Thermal Comfort and Health Conditions in Air-Conditioned Offices in a Warm and Sub-Humid Climate

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ABSTRACT: Over the last couple of decades the use of air conditioning has become a requirement to obtain comfortable indoor environment, especially in buildings located in a geographical location with warm and humid climate, but air-conditioning does not necessarily respond to local consideration of thermal comfort, as a result, occupants feel uncomfortable. One of the main purposes of buildings was to provide healthy and comfortable environments; a poor design of thermal environment affects occupant habitability, causing effects on physical and mental performance. Field studies of the indoor environment in office buildings have proved that the indoor environmental quality was related with many Sick Building Syndrome symptoms (SBS). The objective of this research was to determine the effect of temperature in health problems, and identified the frequency of SBS symptoms in air- conditioned offices located in Colima City, Mexico. The method was based on the collection of weather data and subjective responses in a questionnaire. A total of 414 questionnaires were collected during October 2010 to April 2011in a transversal field study. According to the results, 70% of the occupants presented at least one symptom, the most common problems were: eye irritation, sore throat irritation, runny nose and dry skin.
Keywords: thermal comfort, SBS symptoms, air-conditioning, office.

INTRODUCTION

The use of air-conditioning systems has been increasing dramatically over the last several decades, predominantly in buildings located in warm and humid climate. The purpose of most systems is to provide thermal comfort and an acceptable indoor environment for human occupants; a poor design of thermal environment affects occupant habitability and affects the mental and physical performance. On average, people in industrialized nations spend about 90% of their time indoors [1, 2], especially at home, offices, schools, and other habitable spaces.

Santamouris [3] mentioned that increased living standards in the developed world, which is not characterized by the use of an architecture that responds to the environment, have made air conditioning quite popular. As consequence, office present poor indoor environmental quality, that cause human health problems, often called Sick Building Syndrome (SBS), their prevalence and severity are affected by indoor environmental conditions. SBS symptoms are health symptoms, such as eye, nose, or throat irritation, headache, and fatigue, that are associated with occupancy in a specific building [4].

The aim of this research was determined the effect of temperature in health problems, and identified the frequency of SBS symptoms in air- conditioned office buildings in a warm and humid climate.

HEALTH AND TEMPERATURE

The poor indoor environments quality could affect people health and productivity. Ambient temperatures that are too cool can cause occupant discomfort such as shivering, inattentiveness, muscular and joint tension. The body responds to many diseases or infections of short duration with increased temperature, an environment that is too hot or too cold can affect health; cool conditions can result in impaired mobility due to joint stiffness in the extremities [5].

In a building usually can observe the following symptoms that affect health: headache, throat irritation, eye irritation, fatigue, among others. The presences of one or more symptoms influence productivity, health problems decrease people performance.

The characteristics of the buildings and the environmental conditions inside are related to the presence or prevalence of some symptoms that affect health and performance; some research showed that many building factors are also known or suspected to influence health symptoms including: type of ventilation system; rate of outside air ventilation; level of chemical

and microbiological pollution; and indoor temperature and humidity [6].

The presence of health symptoms in a building is commonly known as Sick Building Syndrome (SBS). SBS has been recognised by the World Health Organisation (WHO) since 1982; symptoms are wide ranging and vary between people, but usually include: eye, nose and throat irritation, dry mucous membranes, runny nose, skin rash, mental fatigue, headache, cough, wheezing, nausea and dizziness.

Thermal comfort affects not only occupant satisfaction; it also affects their productivity [7]. Stoops [5] mention that if something causes the building workers are sick, this will result in low productivity. Considerable evidence proves that SBS symptoms prevalence and severity are affected by indoor environmental conditions as well as by psychosocial conditions [8].

Two projects investigating sick building syndrome were carried out in Germany and Switzerland (Table 1). The ProKlima study was carried out by six interdisciplinary German research groups, 14 German office buildings were evaluated with regard to sick building syndrome in air-conditioned and free-running buildings and the Health Optimisation Protocol for Energy-efficient Buildings (HOPE) project was to define a set of qualitative (prescriptive) and quantitative (measurable) performance criteria for healthy and energy efficient buildings in different European climates [9].

Table 1: Studies mainly related to research in the field of sick building syndrome [9].

PROJECT NAME	YEAR	BUILDING TYPES	OBJECTIVES
ProKlima	1995–2003	NV, AC	Contribution of the indoor climate, energy concept and psychological factors to the illness symptoms and thermal comfort.
HOPE	2002–2005	NV, AC	Benchmarking of 'healthy' and energy efficient buildings, input into CEN standards.

An import research was realized by Nakano, Tanabe and Kimura [10], they analyzed the frequency of SBS symptoms in the thermal environment and founded that SBS symptoms are more related to their thermal sensation votes rather than the temperature itself. The report of the high frequency of SBS related symptoms could be considered to be an indication of dissatisfaction for the given environment. The study was conducted at an office with multi-national workers in Japan concluded that the main factor causing dissatisfaction in the office was the thermal environment.

STUDY AREA

Field measurements of indoor environmental conditions were conducted in eleven air- conditioned office buildings located in Colima City, Mexico. Colima is a small city placed in the middle of the west coast of Mexico: 19° 12' 30" N, 104° 40' 30'' W, and 433 metres of altitude (Fig. 1). Colima is localized in a hot and subhumid region.

Figure 1: Localization of Colima, Mexico [11].

METHOD

Two data collection methods were used: a questionnaire survey was used to obtain the occupants' subjective responses based on the subjective judgment scales of ISO 10551:1995 (E), and physical measurements were used to obtain weather data: dry bulb temperature, wet bulb temperature, globe temperature, relative humidity and air velocity. A total of 414 questionnaires were collected during October 2010 and April 2011. Office buildings and the number of subjects interviewed are presented in Table 2.

Table 2. Office buildings and the number of subjects interviewed.

BUILDING	PERIOD	NUMBER OF OBSERVATIONS	TIPE OF AIR CONDITIONING
A-01	October 2010	8	Central AC
A-02	October 2010	5	Split-system
A-03	October 2010	44	Central AC
	April 2011	12	
A-04	October 2010	7	Split-system
A-05	October 2010	31	Central AC
	April 2011	34	
A-06	October 2010	73	Central AC

	April 2011	101	
A-07	February 2010	19	Split-system
A-08	February 2010	5	Split-system
A-09	March 2010	16	Central AC
A-10	March 2010	12	Split-system
A-11	March 2010	47	Central AC
	TOTAL	**414 OBSERVATIONS**	

In order to obtained weather data we used the QUESTemp°36. The QUESTemp°36 data logging area heat stress monitor measures four parameters: ambient or dry bulb temperature (DB), natural wet bulb temperature (WB), globe temperature (G), and relative humidity (RH), and for measures airflow we used the Quest's Air Probe, the Air Probe uses an omni-directional anemometer sensor that measures air flow between 0 and 20 meters per second in 0.1m/s increments.

To design the questionnaire the investigations realized by: Stoops [5], and Nakano, Tanabe & Kimura [9] were used as reference. The questionnaire was divided into six parts: General information, worker information, thermal perception, weather data and health information (Fig. 2).

HEALTH INFORMATION:				
How often do you experience the following SBS symptoms in your working environment?	0 Never	1 Hardly Ever	2 Sometimes	3 Nearly Always
1. Headache	☐	☐	☐	☐
2. Throat irritation	☐	☐	☐	☐
3. Nasal congestion	☐	☐	☐	☐
4. Skin dryness	☐	☐	☐	☐
5. Eye irritation	☐	☐	☐	☐
6. Difficulty concentrating	☐	☐	☐	☐
7. Fatigue	☐	☐	☐	☐
8. Sleepinees	☐	☐	☐	☐

Figure 2: Fragment of the survey.

For the analysis of the correlation of the frequency of SBS symptoms and the response of thermal comfort, we used bubble charts that correspond to an XYZ graph (dispersion), which compares sets of three values, in this case "X" represents the thermal sensation, "Y" the frequency and "Z" is the size of the bubble represents the total number of observations for each XY value.

RESULTS

According to the results, 70% of the office´s occupants presented at least one symptom of the sick building syndrome (SBS). The most common symptoms were: eye irritation, sore throat irritation, runny nose and dry skin.

The results obtained showed that eye irritation, sore throat irritation, runny nose and dry skin are frequently when the person feel slightly cool (-1), comfort (0) and slightly warm (1).

The figure 3 showed when the thermal sensation was slightly cool, the eye irritation or sore throat irritation were presented by 25 persons in average.

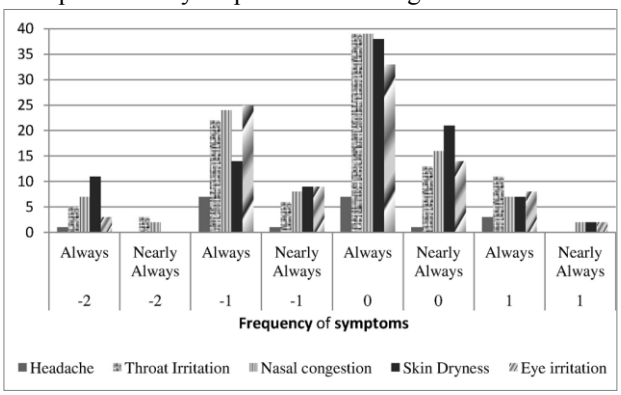

Figure 3: Frequency of symptoms.

The result of the correlation of the frequency of SBS symptoms and the response of thermal sensation, shows that symptoms occur more frequently when the thermal sensation is equal to 0 (neutral) and -1 (slightly cool).

In Figure 4 it is noted that when the thermal sensation was slightly warm (1) and cool (-2), nasal congestion is present at the same frequency level, sometimes. This graph shows that 18% of the occupants presented sometimes nasal congestion.

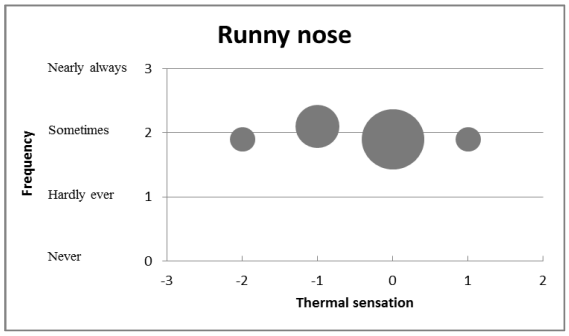

Figure 4: Correlation: thermal sensation and frequency level (nasal congestion).

Figure 5 shows that when the feeling was slightly warm (1) or cool (-2), occupants presents sometimes nasal congestion.

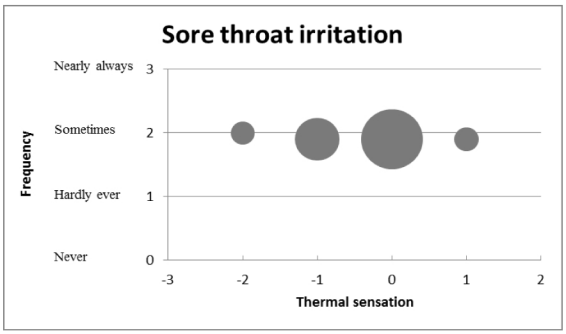

Figure 5: Correlation: thermal sensation and frequency level (sore throat irritation).

Symptom of eye irritation was presented by larger number of workers. When the thermal sensation was comfort (0) 22% of occupants manifested this symptom sometimes, when the thermal sensation was a slightly cool (-1), 10% of people presented sometimes eye irritation (Fig. 6).

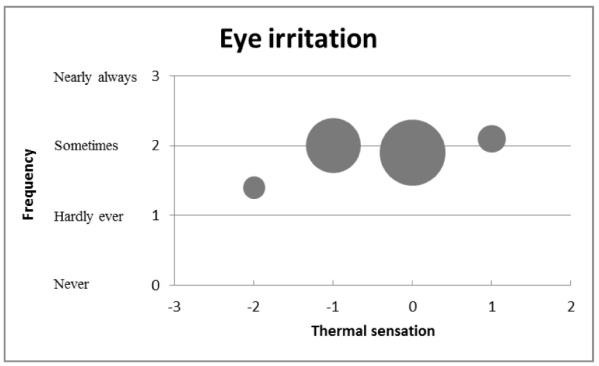

Figure 6: Correlation: thermal sensation and frequency level (eye irritation).

Skin dry is the fourth SBS symptom that people said felt in office buildings with air conditioning. 18% said felt sometimes dry skin during the development of his activities. The figure 7 shows that this symptom had a greater number of responses when the thermal sensation was comfort (0).

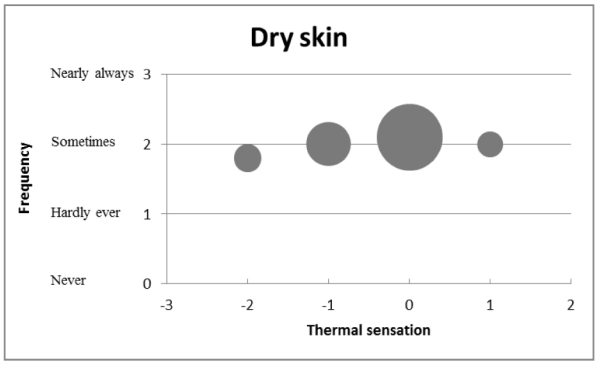

Figure 7: Correlation: thermal sensation and frequency level (Skin dryness).

The most common symptoms were: eye irritation, sore throat irritation, runny nose and dry skin. In most cases we observed that when the thermal comfort is equal to 0 (neutral), the frequency is "sometimes" (2), we detected the same when the answer was -1 (slightly cool).

CONCLUSION

The contributions of this study are important for improving environmental conditions. At present, the thermal comfort of people is implicit in the design of any type of environment, especially when it is desired to control the climate to improve efficiency of the occupants in a workspace.

These findings indicate that greater effort should be placed on design and control of air conditioning in order to avoid sick conditions for users, because indoor environments influence occupant health symptoms as well as comfort.

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