Limiting Criteria for Human Exposure to Low Humidity

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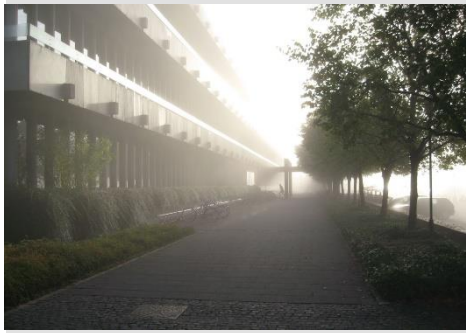
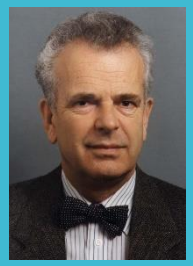


Learning Objectives

1. Understand the effects of humidity on health, comfort, IAQ and on elderly people
2. Understand that healthcare-associated infections increase when the humidity decreases too much
3. Understand the human physiological reactions to low humidity
4. Understand the effects of low humidity on working performance

Reference



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Experimental Determination of the Limiting Criteria for Human Exposure to Low Winter Humidity Indoors (RP-1160)

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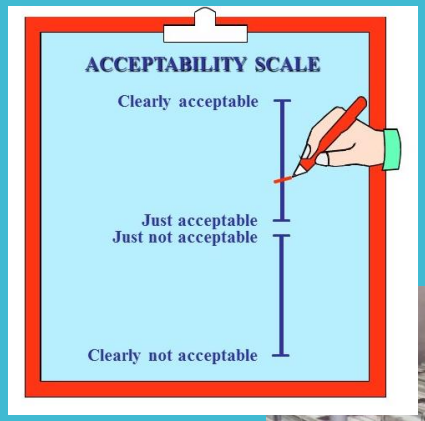
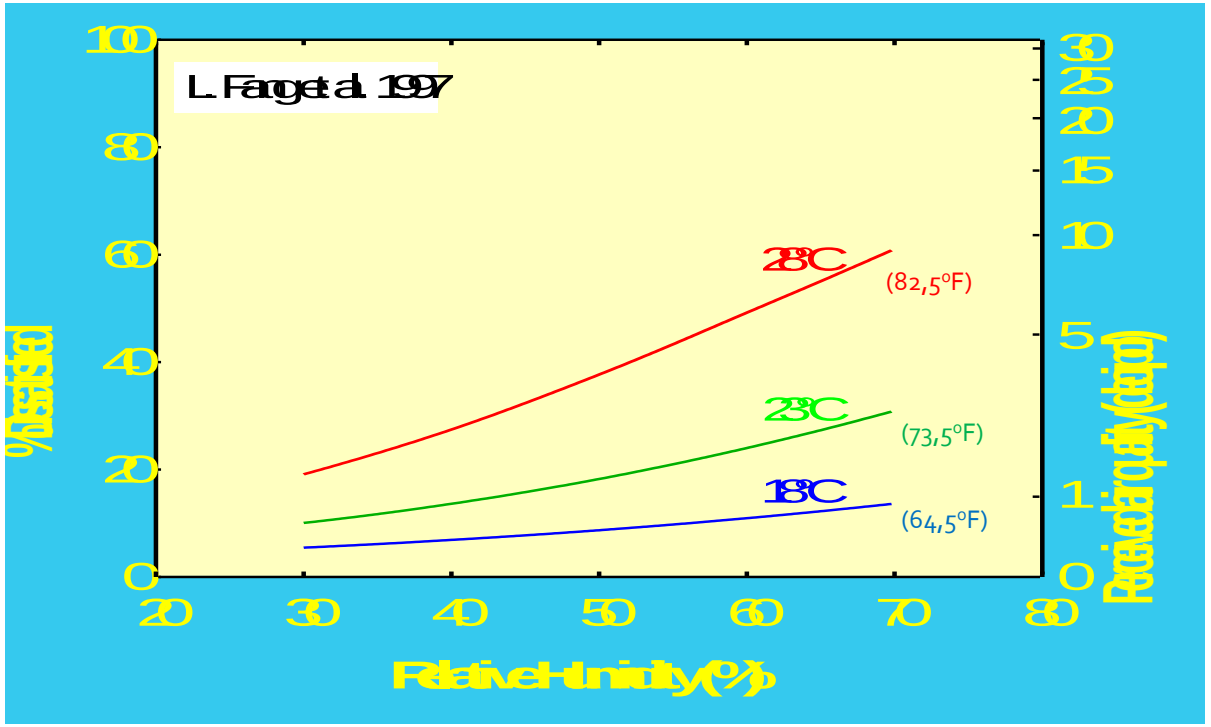
Thirty subjects (17 female) were exposed for five hours in a climate chamber at 22°C (71.6°F) to clean air at 5%, 15%, 25%, and 35% RH. A comparable group was similarly exposed to air polluted by carpet and linoleum to the 35% RH condition and to 18°C, 22°C, and 26°C (64.4°F, 71.6°F, and 78.8°F) at an absolute humidity equal to 15% RH at 22°C (71.6°F). They performed simulated office work to ensure that they kept their eyes open and reported sick building syndrome (SBS) symptom intensity on visual-analogue scales. Nine objective tests of eye, nose, and skin function were applied. Subjective discomfort, though significantly increased by low humidity, was slight even at 5% RH. More rapid blink rates were observed at 5% than at 35% RH ($P < 0.05$), and tear film quality as indicated by the Mucous Ferning Test deteriorated ($P < 0.05$) at low humidity (5%, 15%) and at the highest air temperature 18°C, 22°C > 26°C (78.8°F). Low humidity was found to have reduced the rate of performance of three office tasks by 3%–7%.

Perceived air quality as a function of temperature and relative humidity





Low humidity and the sensation of dryness

Reference	Results	Humidity range
Sundell and Lindvall (1994)	"Sensation of dryness" has little to do with physical air humidity	10 – 40 % RH
Andersen and Proctor (1982)	Dryness of nose do not related to RH	9 – 50% RH
Andersson et al. (1975)	Decreasing relative humidity do not increase the sensation of dryness	25 – 40% RH

Low relative humidity requirements in standards

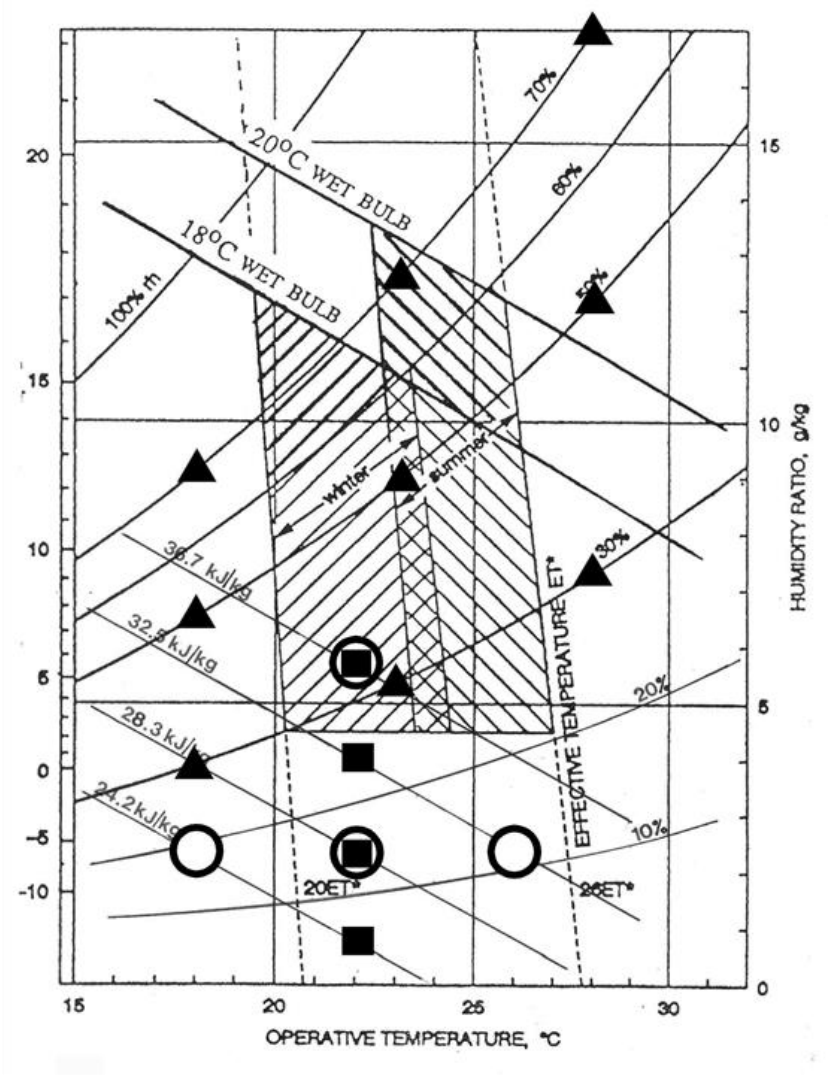
Objectives

- To study the effect (both positive and negative) of low humidity on human health and comfort during a short term exposure
- To study the interaction of low humidity with air temperature and air pollution during a short term exposure
- To verify the sensitivity and suitability of the objective measurements for use in the field experiment

Laboratory experiment

- Clean condition
  - four levels of humidity at 22°C (71.5°F): 5, 15, 25, 35 %RH
- Polluted condition
  - two levels of humidity at 22°C (71.5°F): 15 and 35% RH
  - three levels of temperature at the absolute humidity of 2.4g/kg (15%RH at 22°C (71.5°F)): 18, 22, 26 °C (64.5, 71.5, 80°F)

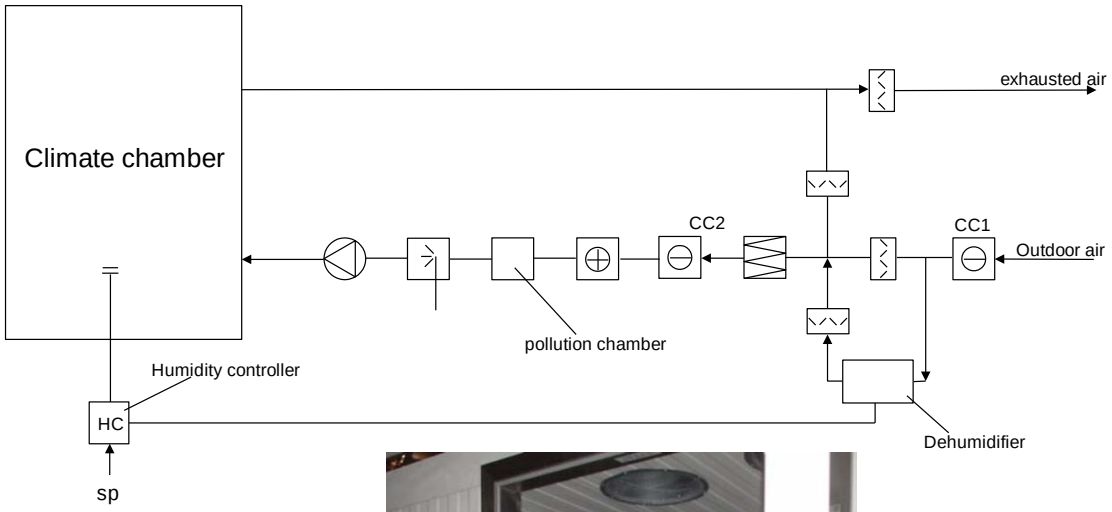
i-x chart


20°C WET BULB
18°C WET BULB
100% rh
70%
60%
50%
30%
20%
10%
Winter
Summer
36.7 kJ/kg
32.5 kJ/kg
28.3 kJ/kg
24.2kJ/kg
EFFECTIVE TEMPERATURE ET*
20ET*
26ET*
HUMIDITY RATIO, g/kg
OPERATIVE TEMPERATURE, °C
20
15
10
5
0
-5
-10
15
20
25
30

Pollution sources:

- carpet (28 m²)
- linoleum (20 m²)

in pollution chamber

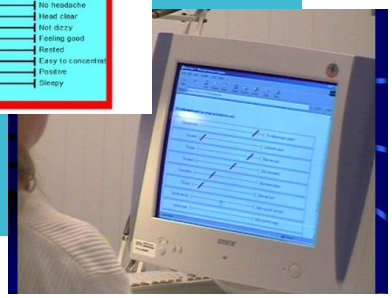


Subjects and procedure

- 60 subjects both male and female including normal, sensitive and contact-lens wearers

- Performing simulated office work during 300 min exposure:
  - Text typing
  - Simple addition calculations
  - Reading

Subjective measure-ments



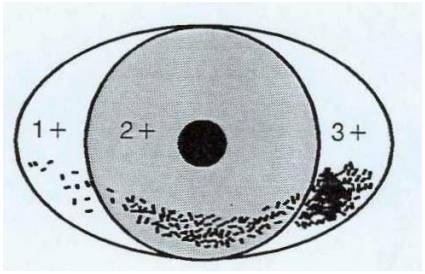
- Assessments of air quality:
  - acceptability and odor intensity
- Specific acute subclinical health symptoms:
  - eye, nose, lip, throat, and skin irritation and dryness
- Neaurobehavioral (general) acute subclinical health symptoms:
  - headache, fatigue, dizziness and alike

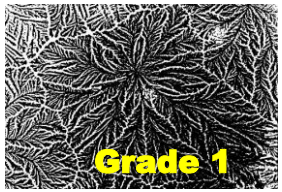
Physiological measure-ments

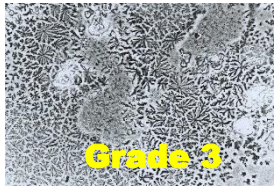
- Eye measurements
- Skin measurements
- Nose measurements

Eye measure-ments:

- Tear film break-up time (BUT)
- Rose Bengal Score
- Inter-blinkrate
- Mucous ferning test





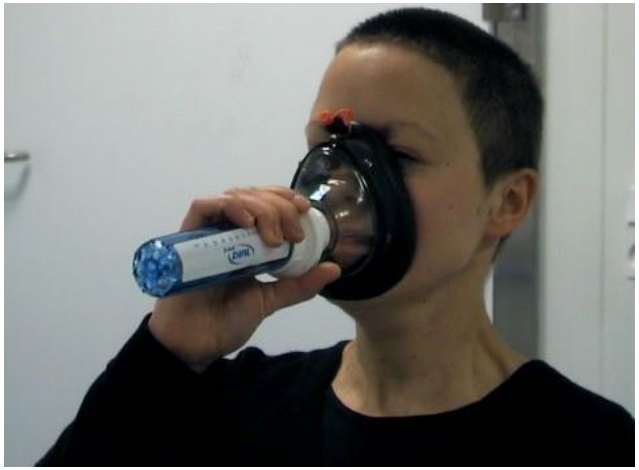


Skin measure-ments:

- Evaporimeter: Transepidermal Water Loss
- Corneometer: Skin Hydration
- Colorimeter: Skin colour

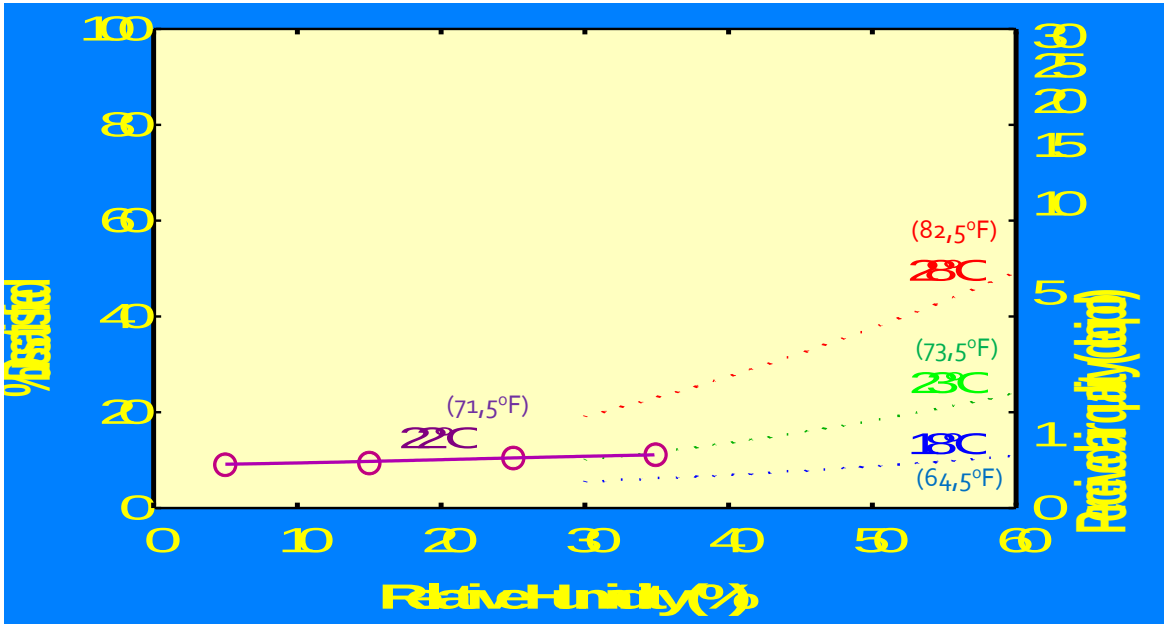
Nose measure-ments:

- Nasal peak-flow
- Nasal transit time



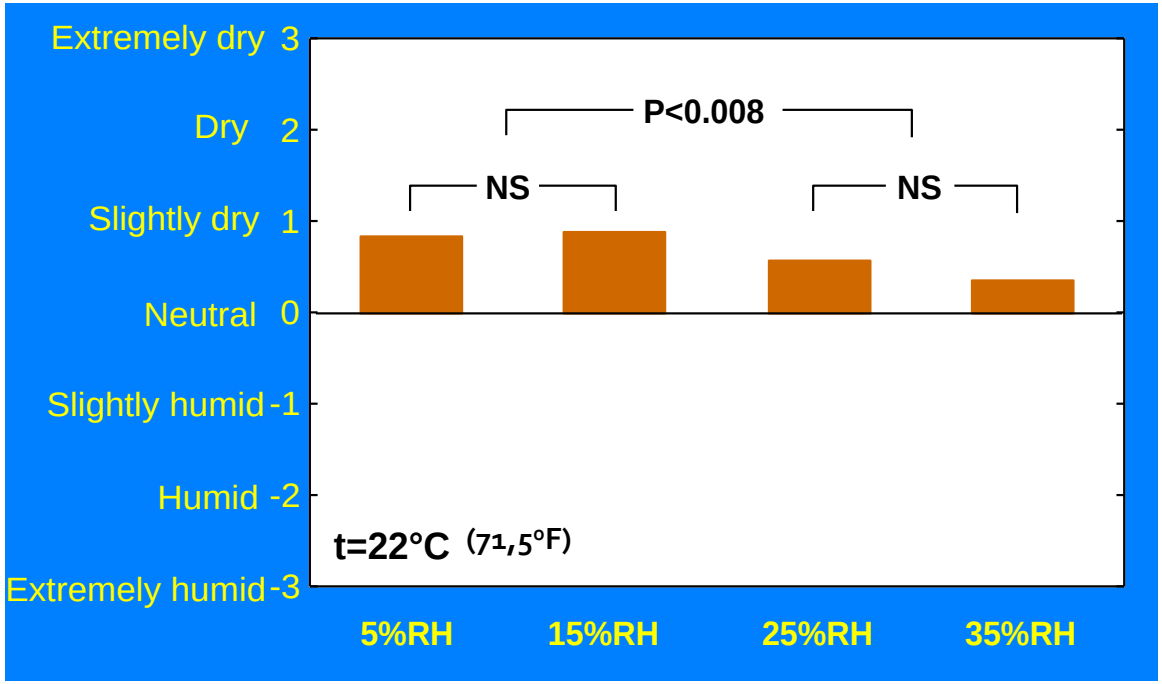
RESULTS:

Effect on perceived air quality



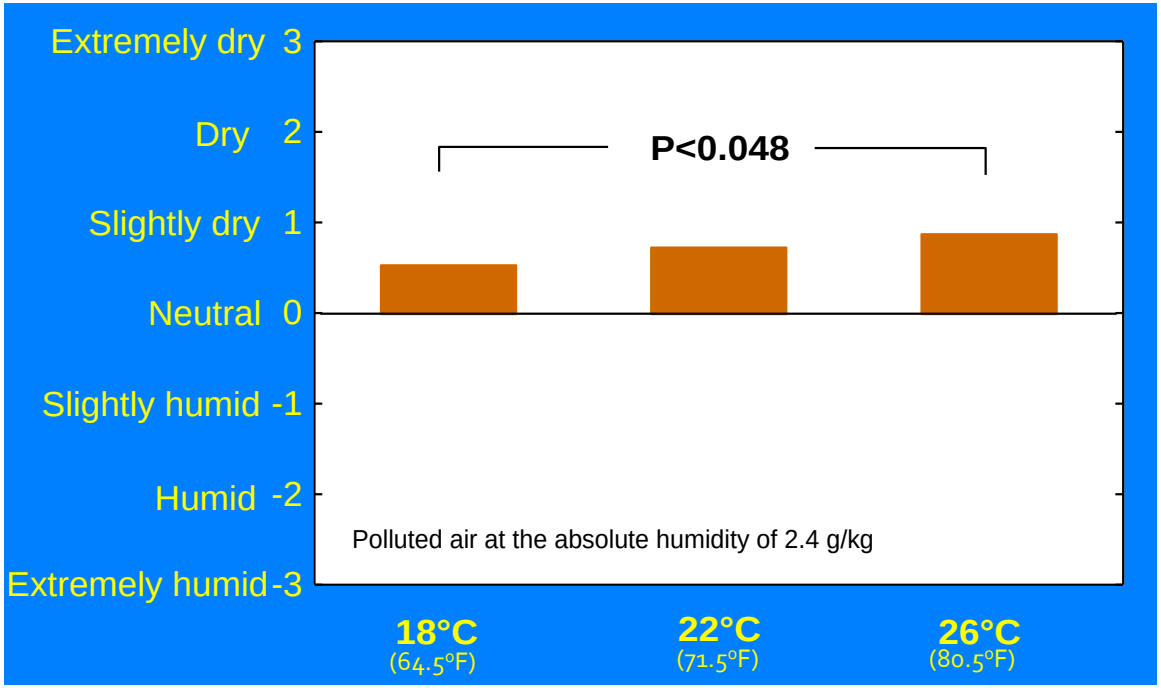
RESULTS:

Humidity sensation @constant temperature (clean air)



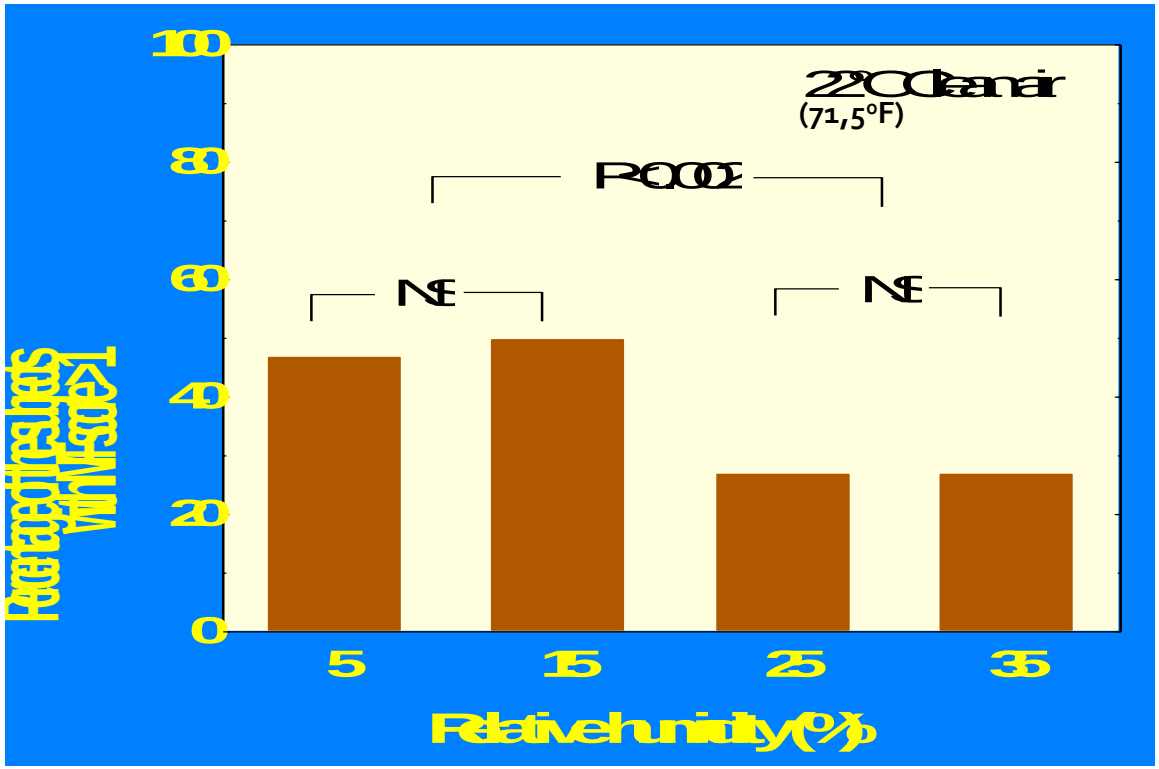
RESULTS:

Humidity sensation @constant absolute humidity (polluted air)



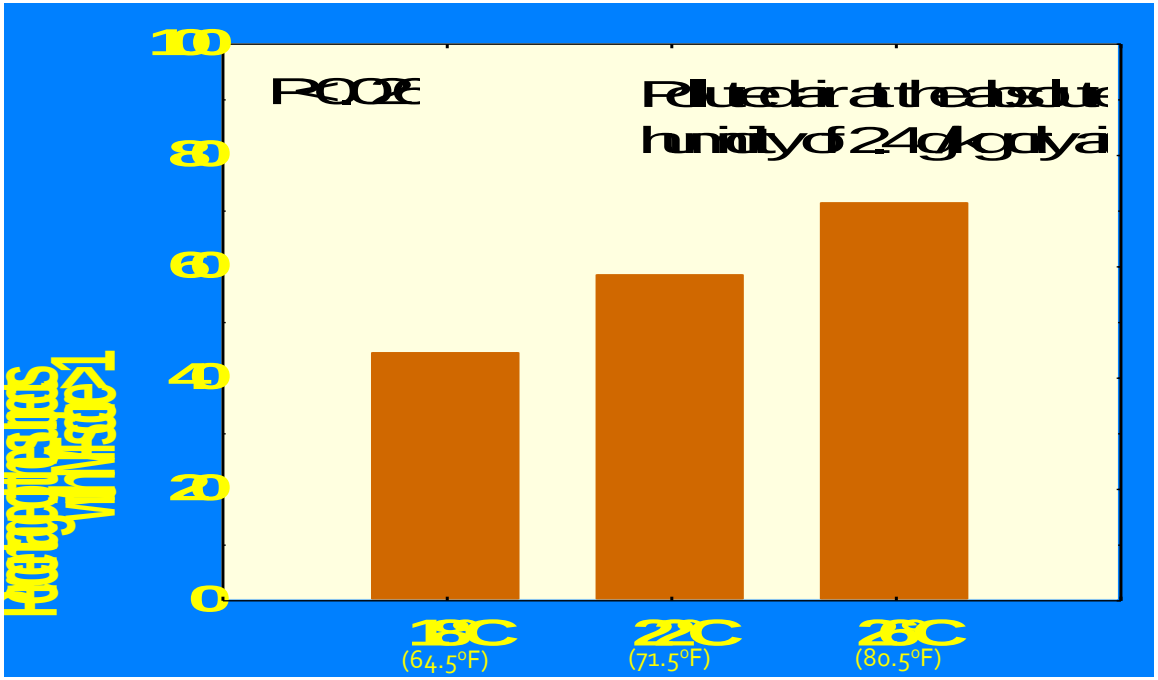
RESULTS:

Mucous ferning (grade 2-4) @constant temperature (clean air)



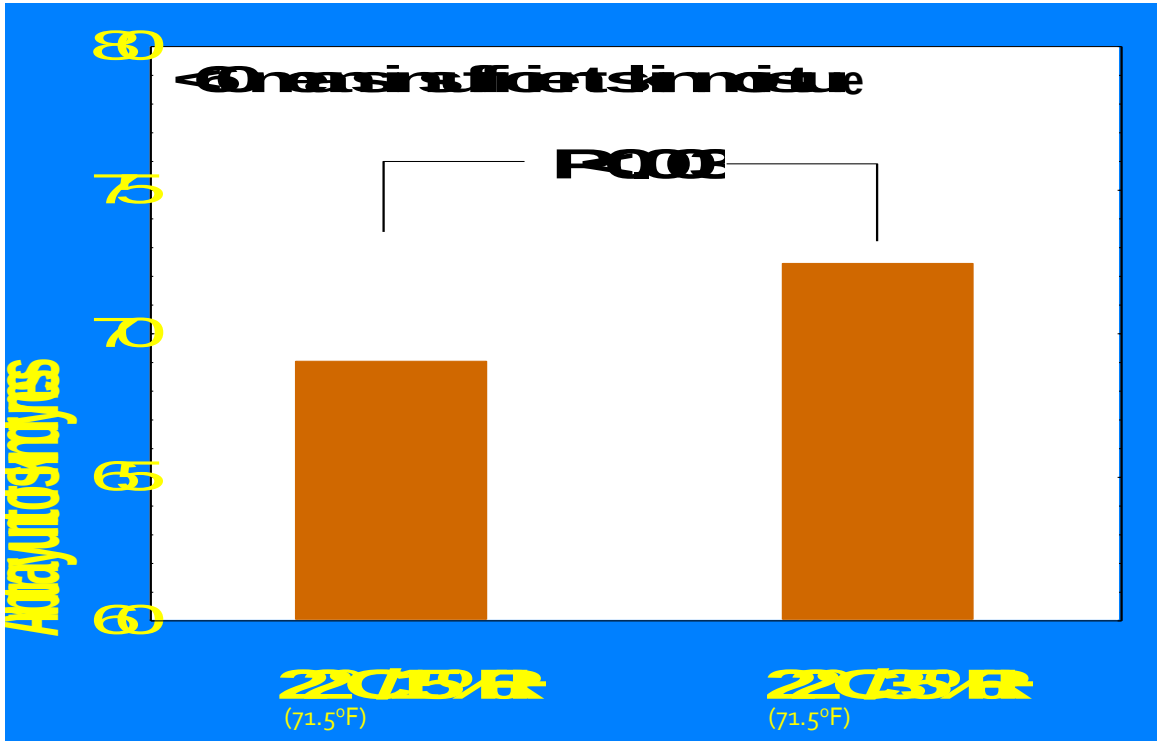
RESULTS:

Mucous ferning (grade 2-4) @constant absolute humidity (polluted air)



RESULTS:

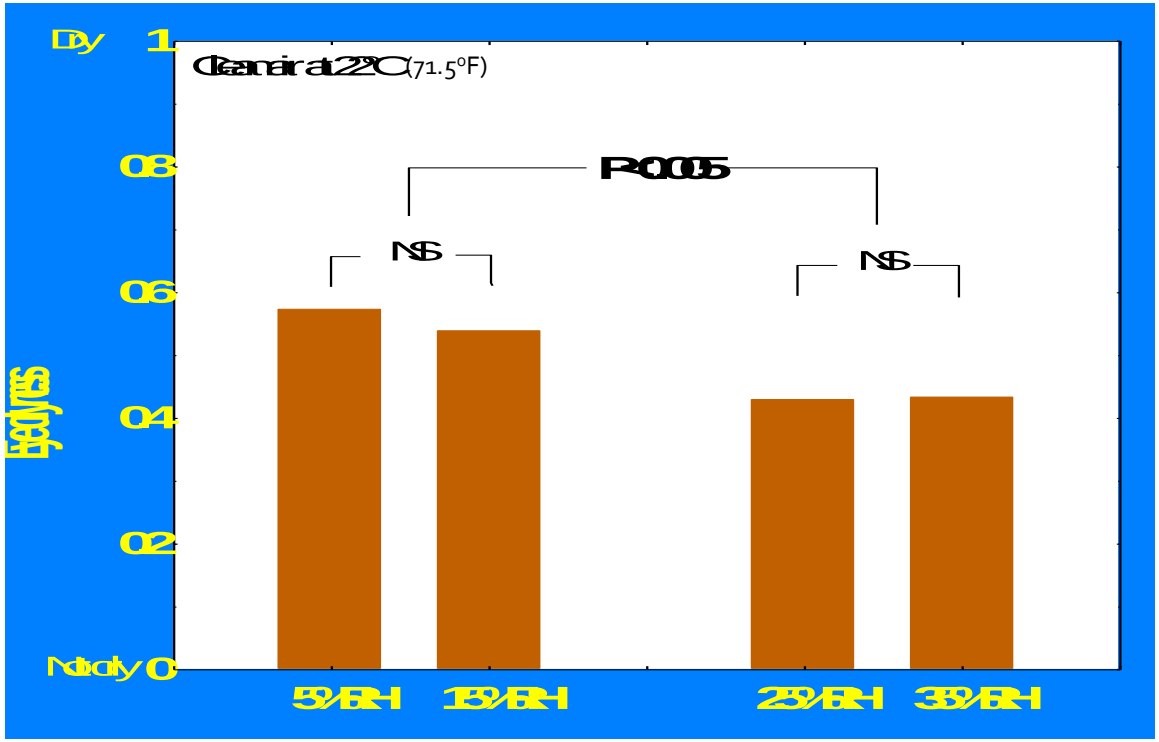
Skin dryness measured by corneometer



RESULTS:

Acute health symptoms (clean air)

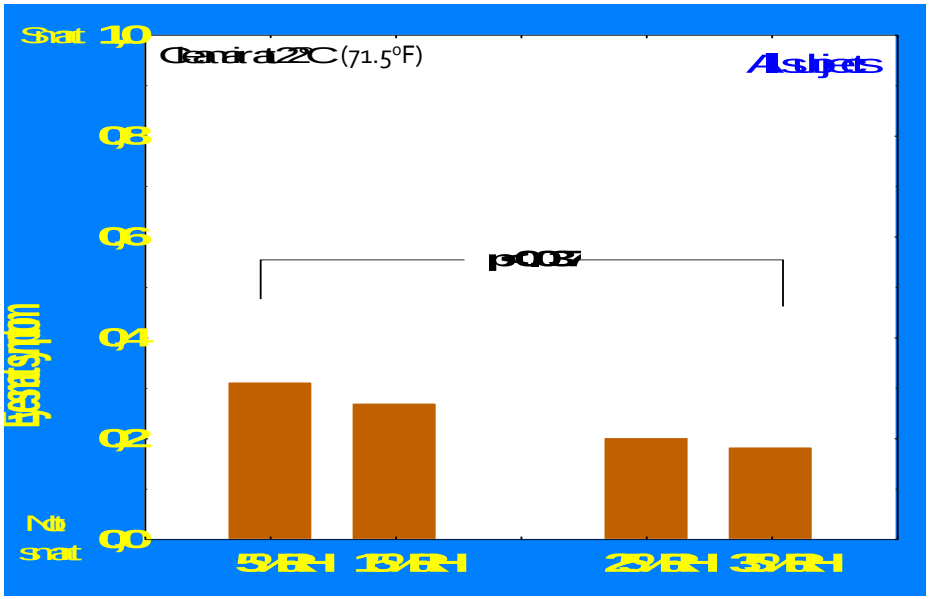
DRY EYES

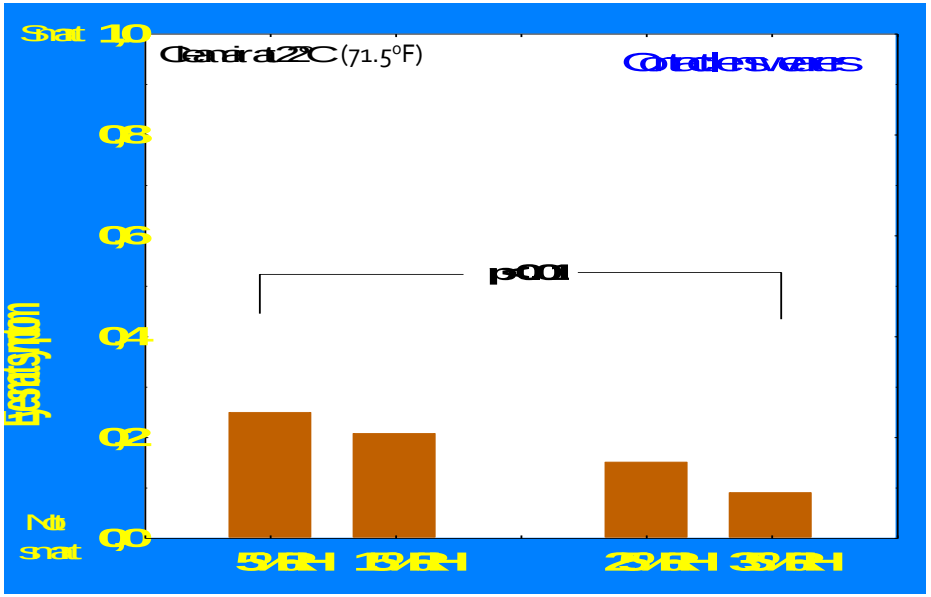


RESULTS:

Acute health symptoms (clean air)

SMARTING EYES

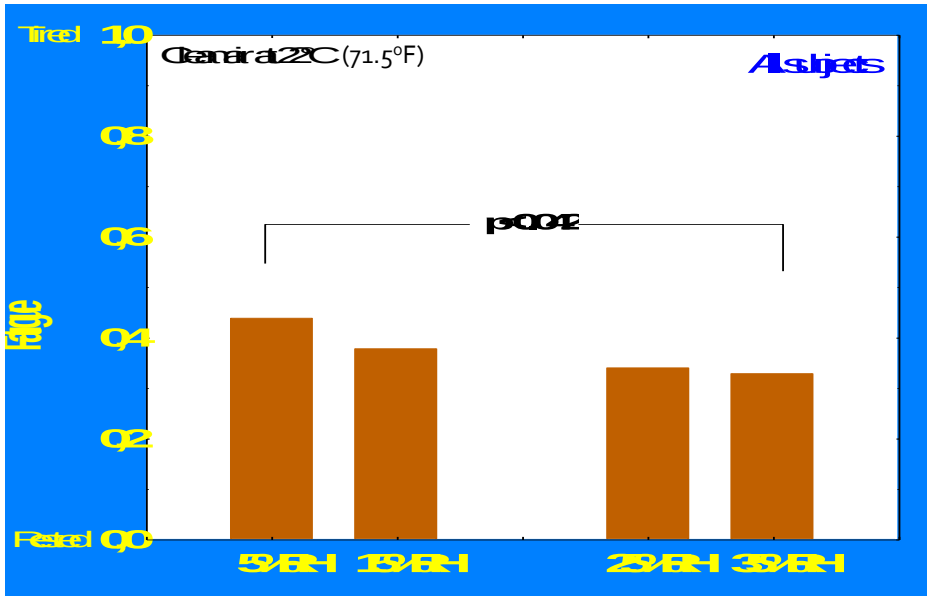


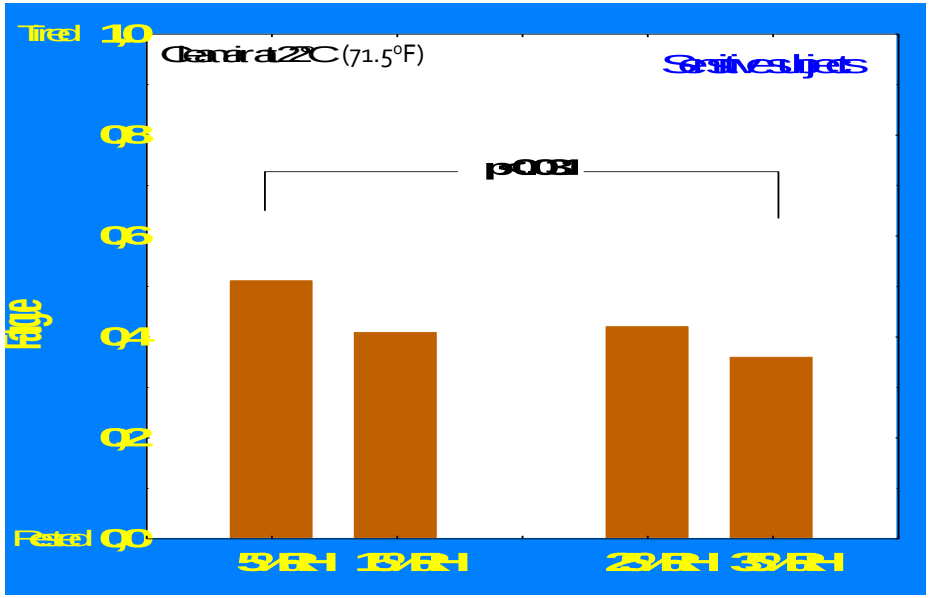


RESULTS:

Acute health symptoms (clean air)

FATIGUE

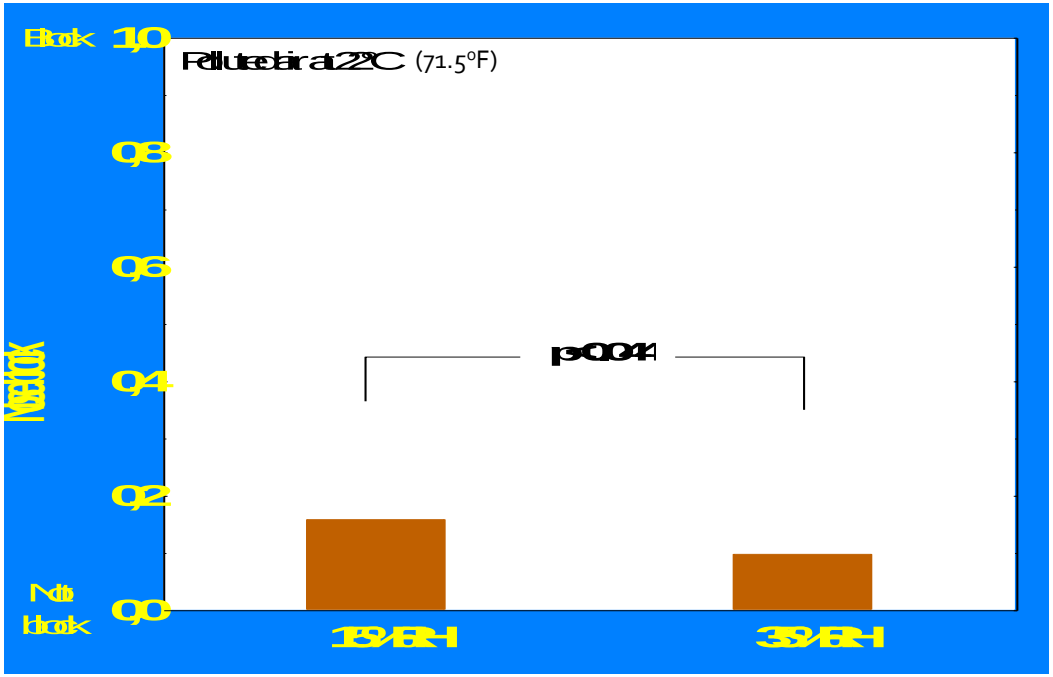




RESULTS:

Acute health symptoms (polluted air)

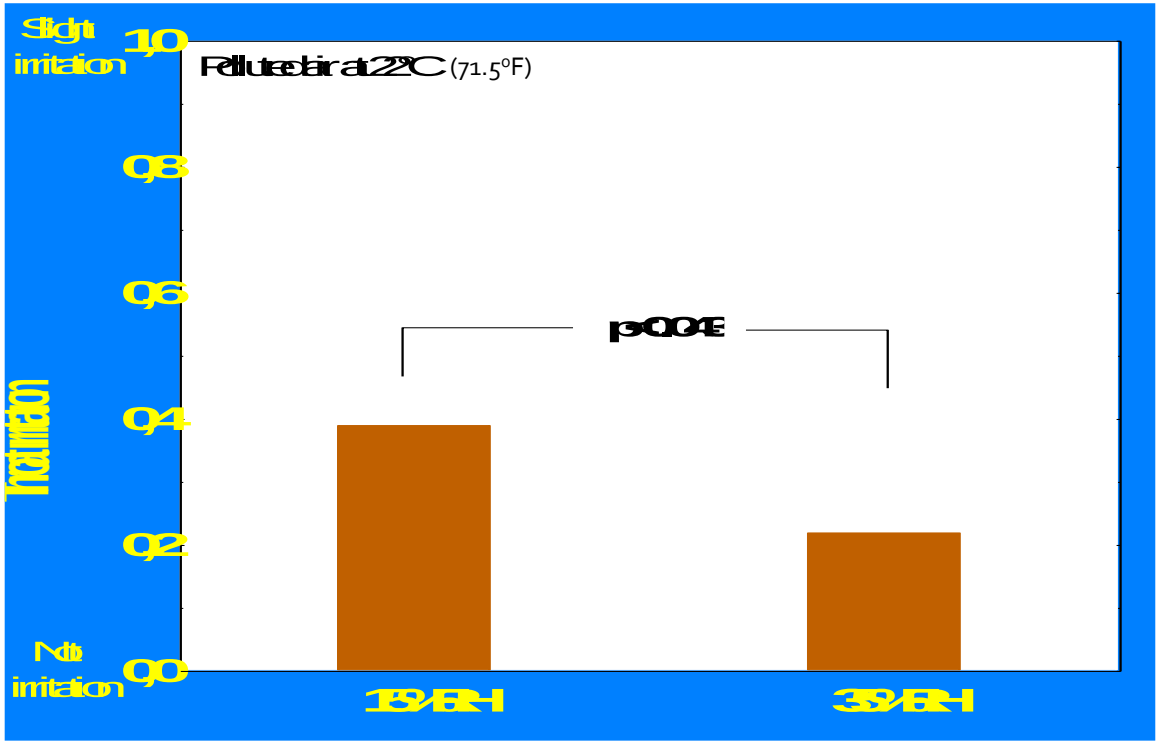
BLOCKED NOSE



RESULTS:

Acute health symptoms (polluted air)

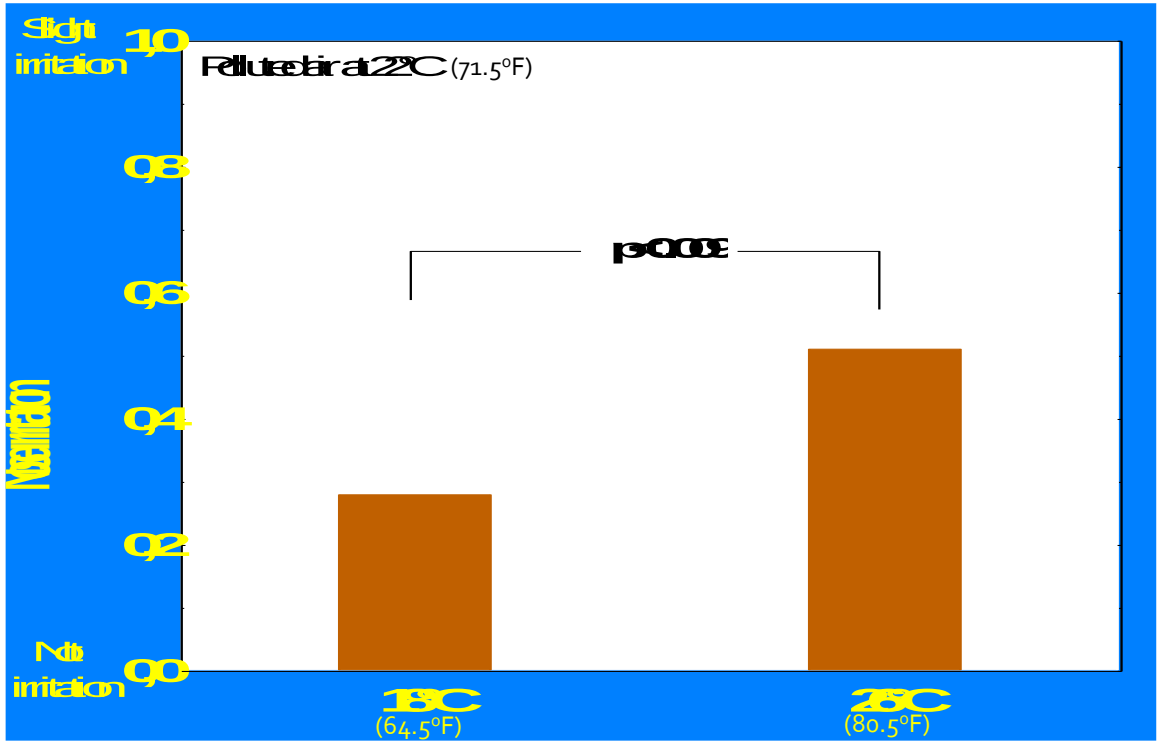
IRRITATION OF THROAT



RESULTS:

Acute health symptoms (polluted air)

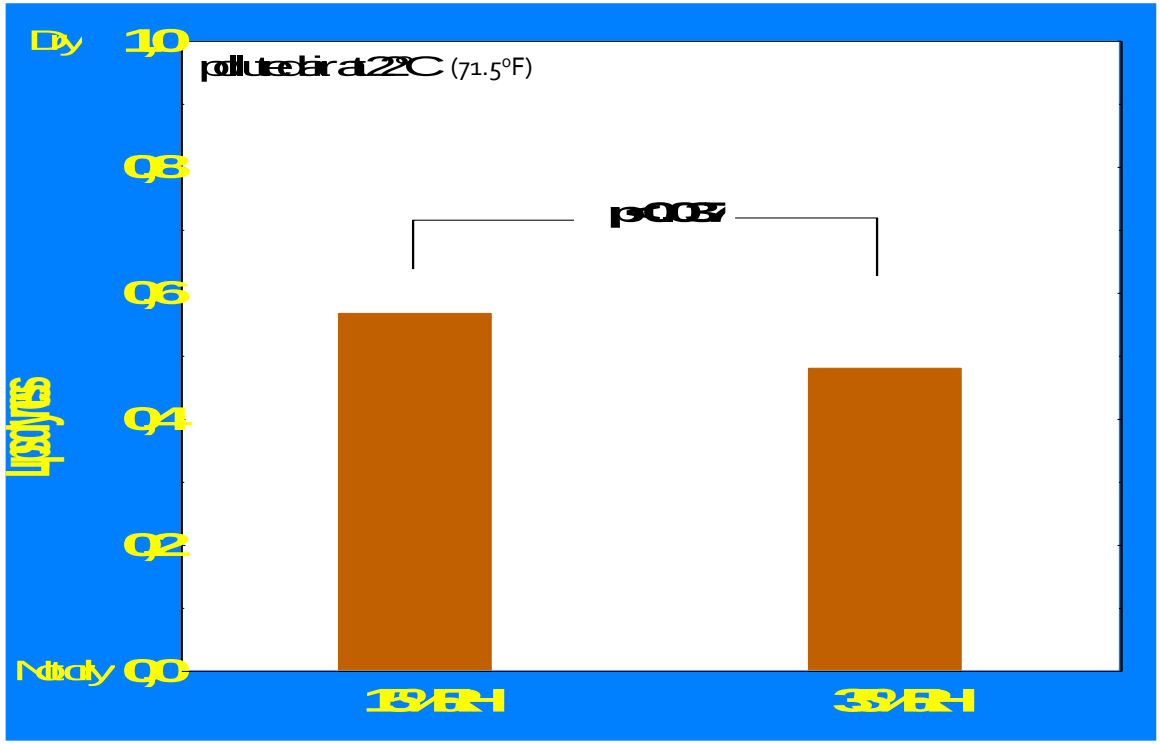
IRRITATION OF NOSE



RESULTS:

Acute health symptoms (polluted air)

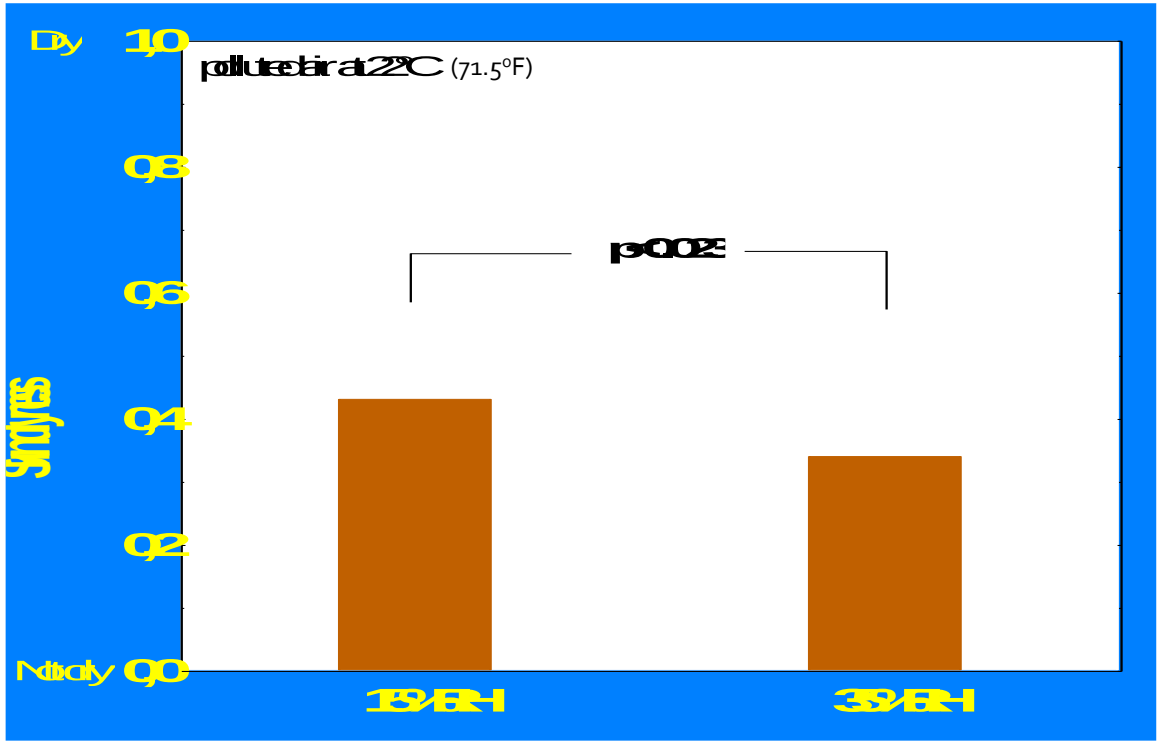
DRYNESS OF LIPS



RESULTS:

Acute health symptoms (polluted air)

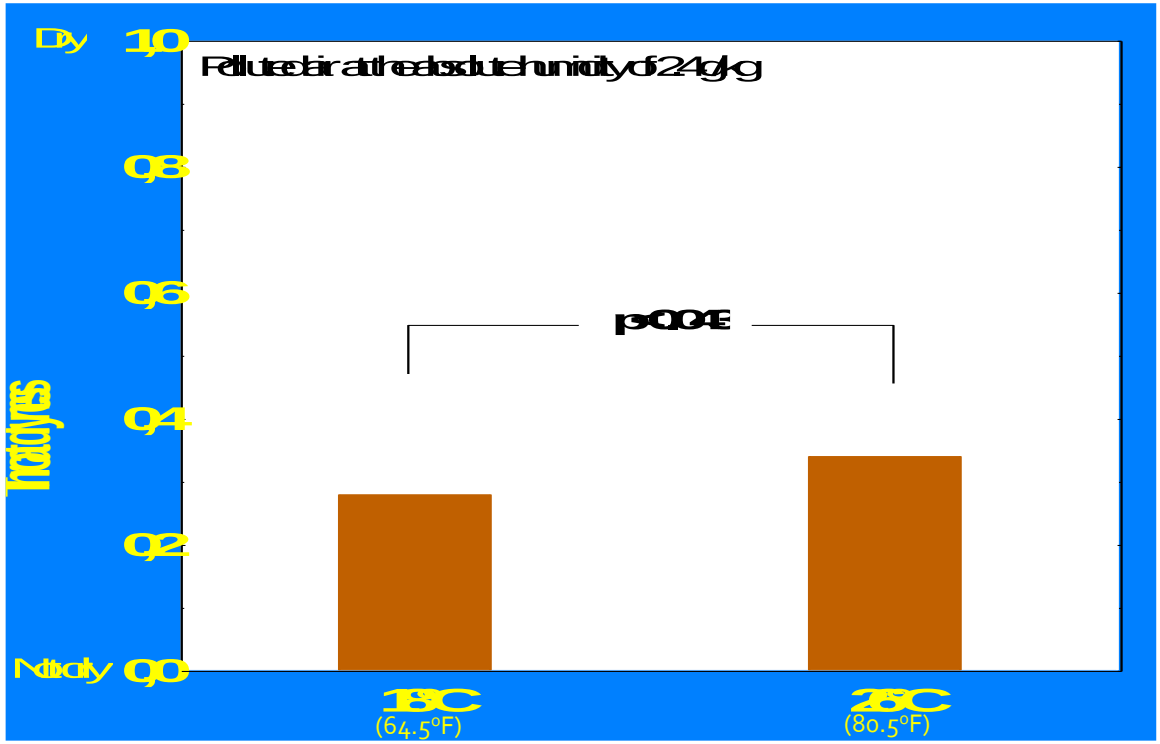
DRYNESS OF SKIN



RESULTS:

Acute health symptoms (polluted air)

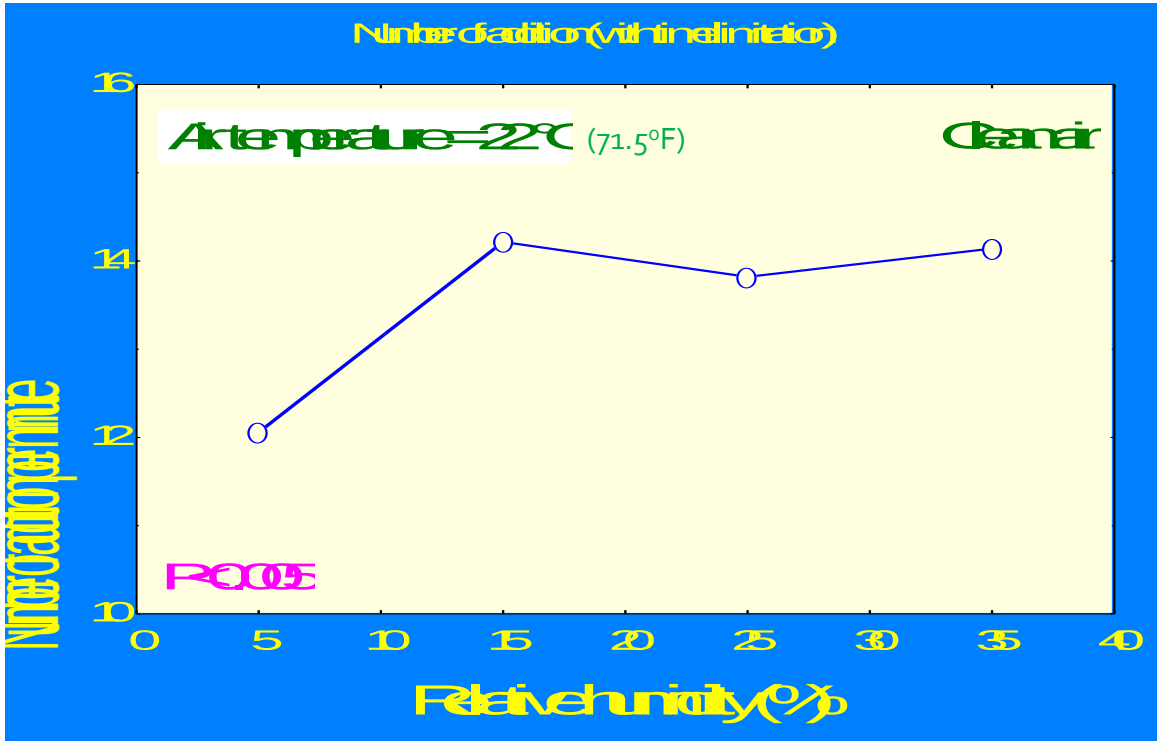
DRYNESS OF THROAT



RESULTS:

Performance

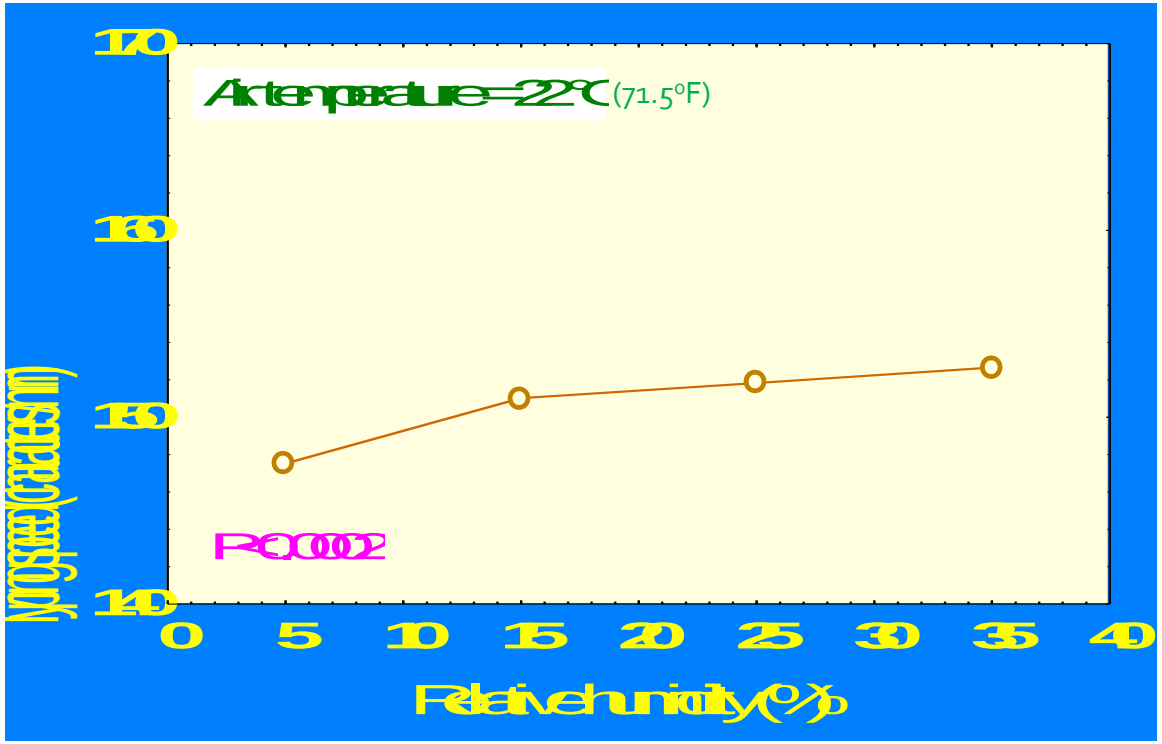
ADDITION (speed)



RESULTS:

Performance

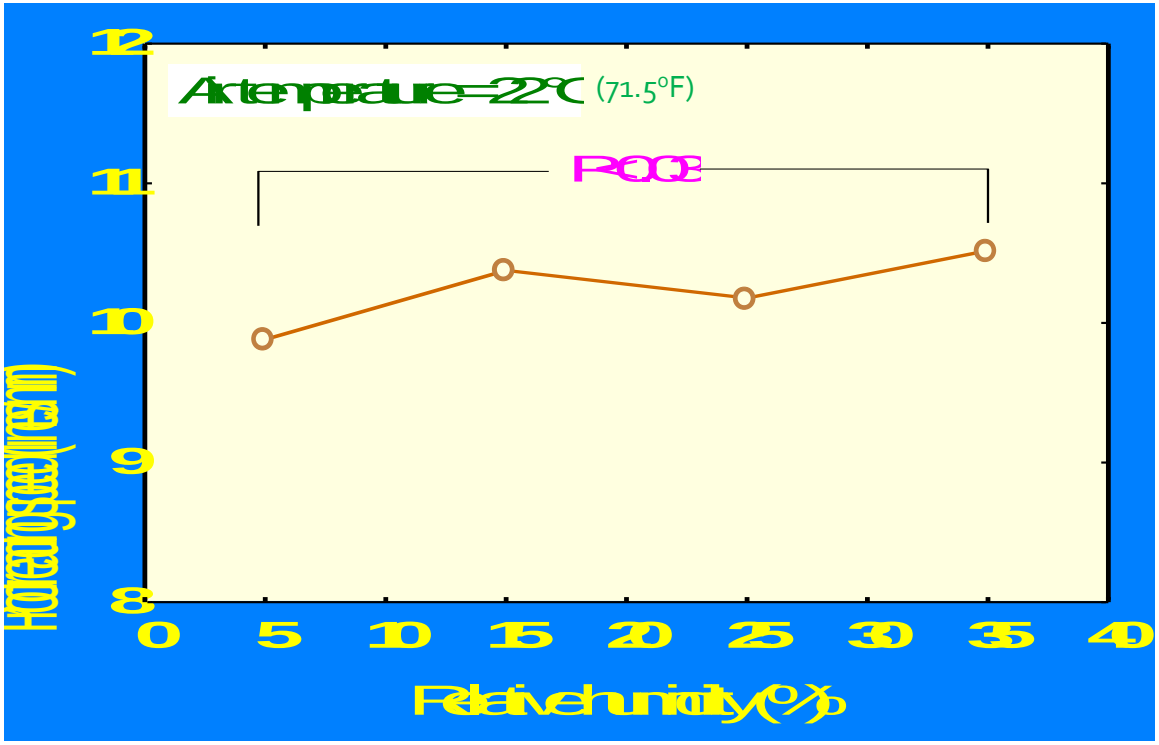
TEXT TYPING (speed)



RESULTS:

Performance

PROOF-READING (speed)

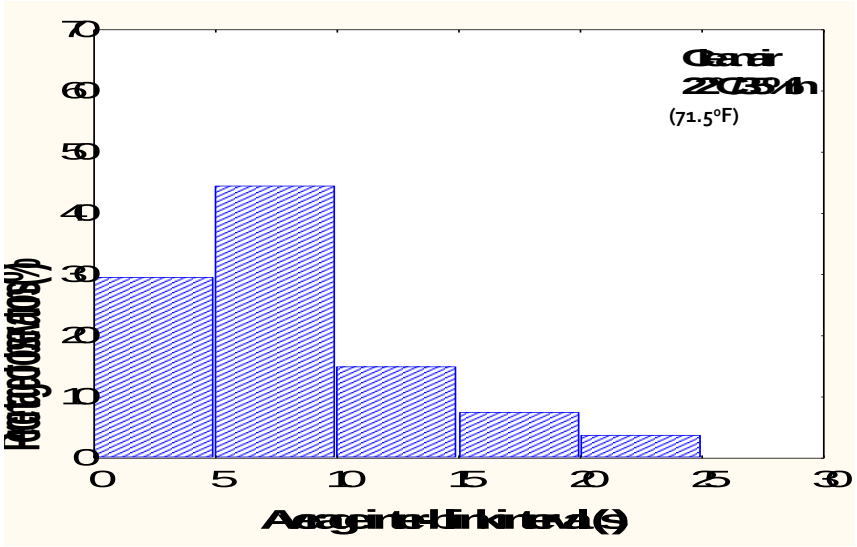


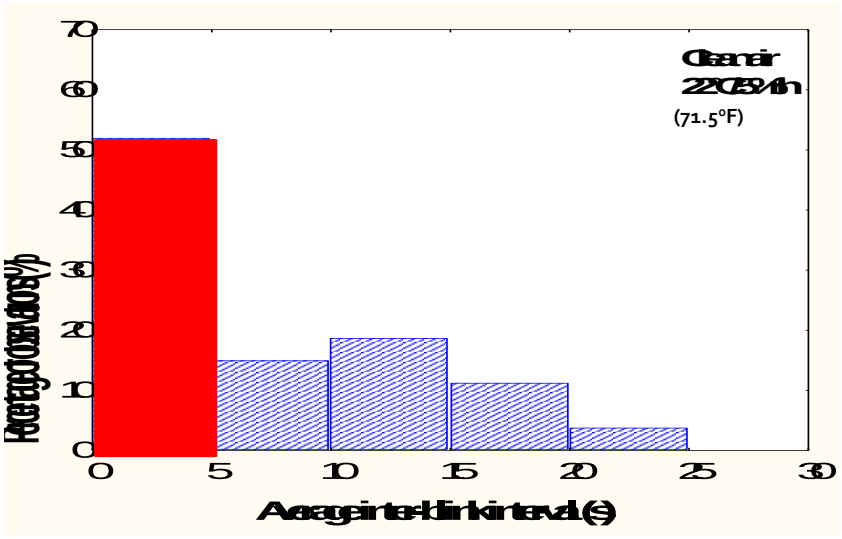
RESULTS:

Blink rate

35% RH
vs.
5% RH

@22°C
(71.5°F) and
clean air





Summary

- Exposure to low humidity for five hours does not create severe SBS symptoms for normal healthy people.
- Exposure to humidity at 15% RH or below for five hours aggravates SBS symptoms for environmentally sensitive people.
- Exposure to high air temperature (26 °C (80.5°F)) at low humidity increases dryness sensations and other related symptoms for environmentally sensitive people.
- Air pollution at normally occurring levels exacerbates the effect of low humidity on the SBS symptoms of environmentally sensitive people.
- Performance of simulating office work decreased considerably when people exposed to the extremely low humidity, e.g. 5%RH.

Conclusions

- Little discomfort was observed when people exposed to low humidity.
- Measurable negative effects (both subject and objective) were observed when people exposed to humidity at or below 15%.
- Air pollution may interact with low humidity and cause throat, nose, skin and lips symptoms.
- Sensitive people is more likely be bothered by low humidity.

Questions and comments

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