Contemporary Ergonomics, Proceedings of the Annual Conference of the Ergonomics Society, University of Leicester, 10-12 April 1996. S.A. Robertson, (ed). 1996: 208-213.

HEAT STRESS IN NIGHT-CLUBS

Marc McNeill and Ken Parsons

Department of Human Sciences
Loughborough University of Technology
United Kingdom

An Internet survey of behaviour, attitudes and opinions of regular club-goers found that night-clubs were considered to be hot or very hot places where many respondents experienced heat related illnesses. The thermal conditions of a night-club were measured (maximum 29^{O}C air temperature, 90% relative humidity) and simulated in a thermal chamber. Four male and four female subjects danced for one hour. The results showed a rise in core temperature (mean=1.8^{0}C, sd=0.26) and skin temperature (mean=1.34^{0}C, sd=0.48) and a sweat rate of almost 1l/h. Subjects generally felt hot and sticky, preferring to be cooler. The physiological responses compared well with predictions from ISO 7933 and the 2-node model of human thermoregulation (Nishi & Gagge, 1977). The predicted effects of continuous dancing for four hours gave a core body temperature increase to 39.1^{0}C, well above the WHO limit of 38^{0}C in occupational settings. Using ISO 7933 appropriate work-rest schedules for dancing and water requirements were suggested.

Introduction

Every weekend an estimated half a million people in the UK go to raves (all night dance parties) and night-clubs (Jones, 1994). They go to dance, often for long periods of time. The ambient thermal conditions of the night-clubs they dance in are often hot and humid. This can put considerable heat stress on those dancing.

Since 1988 there have been approximately 16 fatalities in UK night-clubs (Henry, 1992; Arlidge 1995). Whilst drugs were often implicated, in most instances heat-stoke was the actual cause of death. It is likely that there are also many less serious heat related problems.

The principle aims of this investigation were to assess the thermal conditions in night-clubs and to quantify the behavioural, physiological and subjective responses of people dancing in them. The study comprised of 4 parts, a survey of behaviour in, and opinions on the thermal conditions in night-clubs; an assessment of the thermal conditions of a night-club, measurement of subjective and physiological responses of dancers in simulated night-club thermal conditions and an evaluation of the accuracy of predictive thermal models in order predict the physiological responses to night-club thermal conditions over a period of time.

Survey of behaviour, attitudes and subjective responses to thermal conditions in night-clubs

The population was identified to be predominantly young people (Jones 1994), covering a geographically scattered area. A questionnaire was distributed to subscribers on the UK-Dance discussion group on the Internet and to people outside night-clubs. In total 54 subjects responded to the survey, 65% male, 35% female.

Night-clubs were considered to be hot or very hot places where 61% of people would prefer to be cooler. Respondents generally preferred to drink soft drinks rather than alcohol, many (76%) used drugs such as 3,4-methylenedioxymethamphetamine (ecstasy) for their stimulation. High priced bottled water and disconnected water supplies were given as reasons for low consumption of liquids. In such environments with increased metabolic activity from dancing dehydration was likely, indeed 88% of respondents had experienced heat related illnesses.

Thermal Audit in a Night Club

Night clubs vary in architecture and interior design and each is unique. The auditorium investigated represented a large, high ceiling type, typical of many institutionalised auditoria. Using a Grant Squirrel data logger fixed in the lighting rig, air temperature, radiant temperature and relative humidity were recorded every five minutes over a period of three nights.

A maximum air temperature of $27^{O}C$ and 82% relative humidity were recorded in the auditorium during each night. These measurements were made at approximately 2m above head height. Using a hand held Solex humidity/temperature meter the maximum air temperature and relative humidity amongst those dancing were $29^{O}C$ and 90% respectively. Air velocity in the empty auditorium was 0.175m/s. With a total of 180 lamps rated between 150-750 watts a significant radiant heat load was expected, however the positioning of the Squirrel data logger prevented the black globe being placed under any direct radiant load, hence the true extent of this thermal load was not seen in the results.

Investigation into the Physiological Responses in a Night-Club

Method

The thermal conditions of the auditorium were simulated in the thermal chamber. A pilot study was conducted to evaluate and improve the experimental methods. Aural, oral and Ramanathan's four point mean skin temperature (Parsons 1993), metabolic rate, heart rate and amount of sweat loss were all measured. Eight subjects were exposed to the experimental conditions over two sessions. In each session there were four subjects, two males and two females with a mean age of 21.75 years and wearing clothing of an estimated value of 0.7 clo. They were weighed semi-nude then thermistors were securely attached. Subjects danced for 30 minutes with their metabolic rates being taken using the

Douglas bag method for 2 minutes after 25 minutes. A five minute break allowed them to rest whilst the music was changed. They then continued to dance for the remaining time, their metabolic rates again being taken after 55 minutes.

Finally they were weighed semi-nude with their clothes being weighed separately in a plastic box. All measurements were repeated to ensure accuracy. After weighing they were given soft drinks, offered a shower and discussed the investigation.

Results

The mean aural temperature rose gradually for 15 minutes before flattening. The inadequacies of the measuring techniques for this application were identified. The ear thermistors for three subjects lost contact and were therefore unreliable. When these results were removed, the mean rose to a maximum of 38.2^{O}C, sd=0.25 (Fig 1). The mean 4 point mean skin temperature rose at a similar rate from 36.9^{O}C-38.2^{O}C sd=0.5. The five minute break was sufficient to elicit a decrease in skin temperature of 0.56^{O}C.

The anticipated difference in metabolic rate between the two different styles of music was not found. The discrepancy between the actual and expected results may have been due to more athletic dancing in response to preferred music being heard.

Heart rate was sustained at a mean of 140 bpm. The heart rates of the females (who were considered to be fitter) were lower than those of the males. The heart rate was correlated with the measured metabolic rates in order to estimate the mean metabolic rate for dancing to be 238 W/m^2.

The results suggested that night-clubs present stressful conditions to those dancing. It was not possible to assess the effects of a prolonged exposure in the simulated conditions. The 2-node model of human thermoregulation (Nishi & Gagge, 1977) and ISO 7933 were therefore used to predict how the human thermoregulatory system responds to night club conditions over an extended period of time. The thermal conditions found in the night-club were used in the models, air and radiant temperature being 29^{O}C, air velocity 0.175m/s and relative humidity being either 70% or 90%, the later being the maximum humidity recorded. A metabolic rate of 238W/m^2 was used. The models were run on PC's, the predictions generated being compared with the results from the laboratory investigation to evaluate their accuracy.

The 2-node model over estimated the 4 point skin temperature. It was more accurate with core temperature, (Fig. 1). The predicted core temperature did not account for the five minute rest that was observed in the actual core temperature. Towards the end of the experiment the actual temperature exceeded the predicted temperature. This may have been due to the increase in activity by subjects towards the end of the investigation. ISO 7933 also accurately predicted trends in the rise of core body temperature. The effects of a four hour exposure were then predicted, this being the mean time that subjects in the survey danced for. The 2-node model predicted a core body temperature increase to 39.07^{0}C (table 1). This is well above the WHO limit of 38^{0}C in occupational settings. Using ISO 7933 appropriate work-rest for dancing and water requirements were suggested. This can be seen in table 2.

Conclusions and Recommendations

1. Night-clubs operate at stressful temperatures and humidity. This can predispose those dancing in them to heat strain. Suitable measures such as increased air velocity should be taken to reduce the thermal stress.

2. "Chillout" rooms at lower temperatures to the main dance floor should be provided for rest and cooling of body temperature.

3. Frequent rests should be taken between periods of dancing; after 40 minutes of dancing, a 20 minute rest should be taken in a “chillout” room.

4. Adequate amounts of water should be consumed by those in night-clubs to prevent dehydration. It is suggested that this should be 1 litre/hour for active and prolonged dancing, however over consumption of fluids should also be avoided and advice should be provided.

5. Provision of free, cool, drinking water should be made compulsory.

6. The 2-Node predictive model for human response to thermal environments proved to be a fairly good representation of the actual environment observed. With care this can be used to make further predictions.

7. ISO 7933 accurately predicted the times of exposure before alarm limits were reached and over-estimated times before danger limits were reached.

8. Club goers should be educated as to the risks of heat strain illustrated in this report. This could be made possible with a simple wet bulb globe thermometer (WGBT), displaying the thermal conditions in clubs and the likely effects of dancing in the environment.

References

Arlidge J (1995) *Ecstasy drug condemned as ‘dance with death’* The Independent Thursday 16 February

ISO/DIN 7933 (1989) *Hot Environments- analytical determination and interpretation of thermal stress using calculation of required sweat rate* International Standard Organisation Geneva

Jones D (ed.)(1994) *Equinox November 1994: Rave New World, programme transcript* Channel 4 London

Henry (1992) *Toxicity and deaths from 3,4-methylendioxymethamphetamine (“ecstasy”)* The Lancet, Vol. 340 384-387

NIOSH (1986) *Occupational Exposure to Hot Environments* National Institute for Occupational Safety and Health DHSS (NIOSH) Publication No. 86-113 Washington DC

Nishi Y and Gagge A P (1977) *Effective temperature scale useful for hypo- and hyperbaric environments* Aviation Space and Environmental Medicine 48 97-107

Parsons (1993) *Human thermal environments* Taylor and Francis London

WHO (1969) *Health Factors Involved in Working Under conditions of Heat Stress* Technical Report Series No. 412. Geneva

Acknowledgements

The authors would like to thank Trevor Cole for technical support during the experimental study. In addition, acknowledgement must be made to all the subjects who gave up their afternoons to dance and to Mark Camp who provided the music.

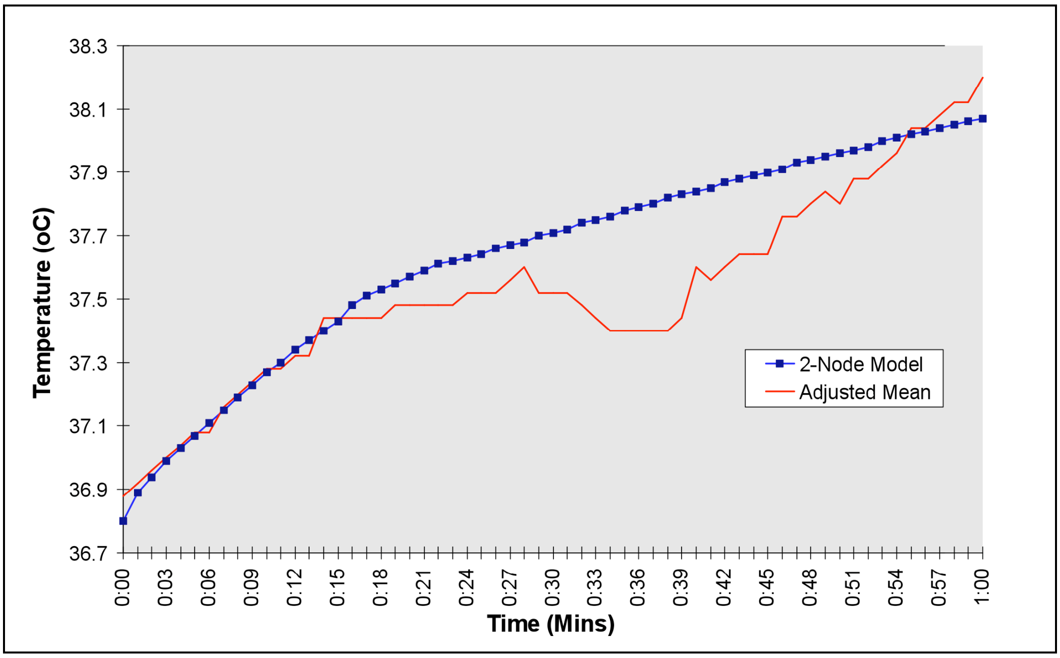

Fig 1. *Predicted and actual (adjusted) core temperatures*

Table 1. *Predicted physiological responses to dancing in a night-club from 2-Node model.*

Exposure (Ta=Tr=29°C)	**Final Body Temp (°C)**
1 hour (rh=70%)	38.07
1 hour (rh=90%)	40.71

Table 2. *Predicted maximum exposure times and sweat required to maintain heat balance from ISO 7933 (Ta=Tr=29°C)*

Exposure	**Alarm Criteria Mins.**	**Danger Criteria Mins.**	**SW_{req} (g)**
1 hour (rh=70%)	43❶	52❶	997.2
1 hour (rh=90%)	30❶	36❶	1007.4
4 hour exposure, 45 mins. dancing, 15 mins. rest	124❶	149❶	756
4 hour exposure. 40 mins. dancing, 20 mins. rest	312❷	390❷	192.3

❶ Rise in core body temperature
❷ Excessive water loss