Field Studies of Heat Stress in Fighter Operations in Assam Valley

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THE study of thermal stress in fighter operations in our Western and North Eastern borders has been carried out in the past in order to evolve methods to protect the aircrew from thermal stress and to keep them at peak efficiency during flight. The problem of heat stress is further aggravated in the Assam valley due to high humidity conditions throughout the year. The present study was carried out primarily for the assessment of thermal stress in aircrew engaged in fighter operations in high environmental temperatures and high humidity conditions.

Material and Methods

The study was conducted at one of the airfields in the Assam valley using a supersonic fighter trainer aircraft. The airfield located at a height of 230 ft ASL had a maximum summer temperature range of 30—35°C, relative humidity from 70% to 90% and average rainfall of 150" per year. The aircraft had a turbocooler system for cabin atmosphere control.

The environmental temperatures as well as the physiological parameters were recorded during preflight, inflight and postflight phases. The routine operational flight profiles were adopted (Table-I)

TABLE—I
Flight Profiles

Sortie	Cruising speed in Mach	Height flown in Km	Flying clothing assembly
Low level strike	0.6	0.1	Subsonic
Medium altitude	0.6-0.8	5-11	Subsonic
High altitude	0.6-0.8	7-15	Supersonic

Two sorties were flown as per each flight profile. The author, seated in the rear cockpit, was the subject in all the sorties. The dry and wet bulb temperatures were recorded during the preflight, inflight and postflight phases, viz., in the crew room, on the tarmac, inside the cockpit at take-off point, inflight at five minutes intervals from take-off and on landing. The canopy was in closed position during taxying. The subject's weight was recorded before flight while wearing undergarments only. The pulse rate, oral temperature and skin temperatures of the subject and the environmental temperatures were simultaneously recorded in the three phases of flight. The oral temperature was recorded using a clinical thermometer. The skin temperatures were recorded with a flat bulb thermometer from the left side of the chest and right leg, the thermometer being kept covered with water-soaked lint. The bulb was dried by wiping with dry lint and was kept in close contact with the skin for 20 seconds before the readings were taken. The mean skin temperature (MST) was calculated using the equation, MST = 0.6 chest temp. + 0.4 leg temp. The mean body temperature (MBT) was calculated using Burton's formula, i.e., MBT=2/3 oral temp. + 1/3 MST. The subject was weighed 15 min after landing so that there was sufficient time for the undergarments to dry up. No fluids were allowed during this period nor was the subject allowed to pass urine. The sweat loss was calculated from the difference in weights before and after the sortie. The heat accumulation in Kcal/hr/m² body surface area was calculated by the formula :

$$\frac{\text{Wt in Kg} \times \text{Specific heat of body (0.83)} \times \text{rise in MBT in °C}}{\text{Surface area in m}^2}$$

Results

In the two low level strike sorties, in the 15 minutes between entering the cockpit and take-off, the cockpit temperature increased by 3 to 5°C. Five minutes after getting airborne, the cockpit temperature decreased by 3 to 5°C and there was a subjective sense of relief. As the sortie progressed the cockpit temperature showed a progressive increase. After landing, in the last 10 min period the temperature and humidity showed a rapid increase. The environment was such that it caused severe subjective discomfort. This was markedly felt in the sweat loss of 500 gms in the first sortie.

The two medium level sorties and the two high altitude sorties did not result in significant heat accumulation or sweat loss. The subject felt quite comfortable. Table II gives a brief summary of the results.

TABLE II

Effect of Various Flight Profiles on the Physiological Parameters.

Sortie (Level)		Rise in MBT (°C)	Sweat loss (Gms)	Heat accumulation (Kcal/hr/m²)	Rise in pulse rate (Per min)	Subjective feeling
Low	I	2.1	500	46.93	24	Exhausted
	II	2.9	700	96.17	48	Severely exhausted
Medium	I	-0.5	300	Nil	24	Comfortable
	II	0.5	300	18.35	36	Comfortable
High	I	-0.3	75	Nil	24	Comfortable
	II	0.1	400	22.46	24	Comfortable

Discussion

From the data collected it becomes evident that the problems of thermal stress in fighter operations under high environmental and high humidity conditions arise mainly in low level flights. Most of the thermal stress is due to the high environmental temperature and humidity on the ground raising the cockpit temperature and the time lag between entry into the cockpit and take off. Even before take off due to the reasons stated above there is a considerable amount of heat accumulation. Coupled with this, inadequacy of the cabin conditioning system during low level flights causes further accumulation of heat which may reach maximum tolerance limit though not to the collapse stage. The high environmental temperature and humidity conditions on the ground on landing further impede and delay recovery from the heat exposure. If the same aircrew has to undertake a second sortie before full recovery, he is exposed to a thermally stressful condition with an initial high level body heat which will result in accumulation of heat to the tolerance limit within a short duration with consequent decrement in performance.

According to Blockley et al (1954) heat accumulation of 50 Kcal/m² corresponding to 60% of the collapse level gives rise to appreciable discomfort and decrement in the performance. When the heat accumulation reaches the order of 80 Kcal/m², retention of consciousness becomes difficult. According to Varghese et al the average tolerance level is reached in acclimatised Indian subject when the heat accumulation is of the order of 124 Kcal/m². The deterioration in performance starts after heat accumulation of 75 Kcal/m² corresponding to 60% of collapse level. In the two low level sorties flown in the present study the levels of heat accumulation were 46.93 Kcal/m² and 96.17 Kcal/m² respectively. The heat accumulation in the second sortie was higher compared to the first one because of the clear sky, bright sun and time of the sortie (1330 hrs) which added additional heat load from solar radiations. The level of heat accumulation in the second sortie was well beyond the level at which deterioration in performance could occur though not collapse. In this sortie the subjective feeling was one of severe heat exhaustion. If after such a flight the aircrew had undertaken another flight due to operational or other reasons, even before he had recovered from the effects of first exposure, the outcome could have been disastrous.

If the ORP and crew rooms are properly airconditioned the proplem of thermal stress can be reduced to a great extent. In most airfields, however, the crew rooms are not airconditioned. Properly air conditioned crew rooms and ORP will aid in quick recovery from the previous exposure and improve aircrew combat readiness to a great extent in short time between the flights.

Conclusion

The problem of thermal stress in fighter operations under high environmental temperature and high humidity conditions is mainly in the low level flights. The major source of heat load is during taxying and in low level sortie. The present study was carried out with limited facilities in field condition, but it provides an insight into the problems of aircrew operating in hot and humid environment.