Effects of cold on manual performance

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Human manual performance is adversely affected by exposure to cold. These effects are caused by decrease in hand skin temperature, which reduces cutaneous sensitivity and manual dexterity. Even the most familiar tasks are affected. The time spent on a fairly simple match-lighting task increased from a baseline of 3.7 s to 6.9, 9.8 and 11.3 s after 20 min exposure to −8, −14 and −20°C, respectively. Performance is also affected by central cooling and by the psychological factors that precede or follow exposure to cold. Hands and fingers can be kept warm with gloves and mittens, but these have to be removed periodically for maintenance tasks requiring finger tactility, so deterioration in manual performance is inevitable. Some remedial measures to prevent the ill-effects of cold are suggested.

Keywords: Cold stress, Manual performance.

Indian Air Force has been flying over high-altitude areas for over four decades. Transport aircrafts and helicopters are routinely engaged in logistic support, transport of troops and casualty air evacuation. The operations are carried out at altitudes of 10,000–20,000 ft from bases in the plains and also from forward bases above 10,000 ft. Some of these bases are snow-bound throughout the year, with very harsh living conditions, subzero temperatures (as low as −30°C), intense glare, isolation, unpredictable weather and ever-present danger of survival in case of forced landing or crash. Hypoxia compounds the physiological effects of cold in a complex manner. This paper reviews the effects of cold on manual performance and on the work efficiency of the ground technicians and other support personnel. Some suggestions towards mitigating these effects are made.

Exposure to unaccustomed cold causes intense discomfort and physiological strain. Human task performance is also affected adversely. This decline in performance is due to cooling of extremities, fall in core or central temperature and psychological factors that precede or follow the exposure to cold. At high altitudes, these effects are further modified by hypoxia to the detriment of the operator's efficiency.

Extremity cooling causes a progressive decline in the performance of manual tasks, specially of those involving fine finger manipulation and coordination. Severe decline in knot-tying task performance has been reported [1] when the hand skin temperature (HST) fell to 55°F and it continued to deteriorate rapidly as a function of the duration of exposure. Speed and accuracy of telephonists were found to be adversely affected with the fall in ambient temperature [2]. In a serial choice reaction task an increase in errors by 200–300% has been reported by Ellis [3] when the mean skin temperature fell by about 10°C; task performance returned to normal on rewarming. There was an increase in time of a fairly simple match-lighting task. The average time increased from a baseline of 3.7 s to 6.9, 9.8 and 11.3 s after 20 min exposure to −8, −14 and −20°C, respectively [4]. Egress time from a simulated Harrier cockpit was found increased with increasing exposure to cold [5].

Exposure to cold causes reduction in HST, which affects the performance by numbing/ attenuating the cutaneous sensitivity and manual dexterity [6]. The critical HST for tactile sensitivity [7] is about 8°C and for manual dexterity it is 12–16°C. There is increased viscosity of the synovial fluid due to cooling of joints. Direct cooling of nerve endings may also interfere with nerve impulse conduction. Nerve fibres and receptors are subject to cold blocks below about 6°C and no longer initiate or conduct impulses at these temperatures [8]. Performance is further affected by thick bulky protective clothing, which makes movements clumsy and hampers limb movements.

These effects of cold on cutaneous sensitivity and manual dexterity cause deterioration in the work efficiency of technicians who operate switches, push buttons, knobs, keys, screws, nuts and bolts. It has been estimated that to maintain a vehicle in the Antarctica takes anything up to 20 times longer than when it is done in comfortable temperature conditions [9]. Aircrew are normally not exposed to such severe temperatures except during certain open-door and open-hatch operations, when the HST will be lowered as the gloves which are designed for finger tactility will offer little thermal comfort. This may affect aircraft operations adversely unless the cockpit can be effectively heated.

Excessive drop of central body temperature causes much more serious disorders. Disorientation, confusion and amnesia are well-known symptoms of early hypothermia. In a water immersion test at 15°C, impairment of memory registration was found as body temperature fell below 36.7°C and the impairment was severe at temperatures around 35°C. From a practical viewpoint, this impairment could be hazardous when quick responses are needed [10]. All types of cognitive and psychomotor task performances, especially those requiring sustained attention, are adversely affected [11, 12]. An increase in error rates was found in a serial choice reaction task with increase in information load [13]. Torrance [14] reported the effects of cold on a verbal recall task on exposure to 26.7°C. The group allowed to rewarm recalled about twice as much as the group not allowed to rewarm. These effects are caused directly by the reduced temperature of the brain as shown by some tests done with warm skin to eliminate discomfort. The effects of hypoxia on central nervous system are well known. It will further modify adversely the effects of cold.

There are many reports of abnormal social behaviour and adjustment problems in people exposed to extreme cold conditions during Antarctic and Arctic expeditions and military missions [15, 16]. Increased irritability, anxiety, depression, lethargy, irrational behaviour and deterioration in personal hygiene and morale have been reported. Whether these effects are directly due to cold is subject to controversy since individuals showing these manifestations were adequately protected. Other stressors like isolation, confinement, sensory and sexual deprivation, perceived threat of cold injury and individual differences have been contributory.

Deterioration in manual task performance on exposure to cold is inevitable. Hands and fingers can be kept warm with gloves and mittens but they will have to be removed periodically for maintenance tasks requiring finger tactility and manual dexterity. It should be emphasized that slow cooling has more detrimental effect on task performance than rapid cooling and the effects of slow cooling persist even after rewarming [17]. It is easier to keep warm than to get cold and then try to rewarm. Therefore, prolonged exposure to cold should be avoided. Frequent warming breaks should form part of the work schedule and should be supervised. Further, for the prevention of ill-effects of cold, due importance should be given to psychological selection, acclimatization, preparatory indoctrination, diet, clothing, living conditions and sheltered work stations. Provision of entertainment facilities, survival training, periodic rotation, limited tenure and good leadership will go a long way towards morale and need not be emphasized.

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