Psychological aspects of cold environment

Of all the stressors that affect human mind and body, environmental stress is quite significant, which can be critical in a military context. Extreme cold is a potent stressor causing both deterioration in morale and decrements in performance. Servicemen are expected to perform at optimal levels in all types of climates, including the cold and the extreme cold. Thus understanding the impact of extreme cold weather conditions on mind of soldiers will help them adapt and perform better This chapter reviews changes in human psychological performance seen in mild, moderate and extreme cold environments in an attempt to provide guidance in framing reasonable performance expectations. Finally, some attention is drawn to psychiatric effects of prolonged exposure to extreme cold environments. Some areas where additional training may prove beneficial are highlighted, including the possible role of acclimatization as a method of attenuating performance decrements.

THE PSYCHO PHYSIOLOGICAL ASPECTS OF COLD ENVIRONMENT

The psycho physiological response of an individual to an extreme cold climate depends on four different factors interacting with each other. They are the environment, genetic predisposition, learning or experience and finally perception and behavior [1]. The effects of cold are aggravated by wet and windy conditions; high altitude hypobaric and hypoxic conditions have additive adverse effect [2]. The role of genetics in the psycho physiological responses is controversial. Some evidence suggests that the way the body reacts is different in various resident circumpolar tribes. Yet similar changes can also be induced in nonresident acclimatized persons [3]. Cold stress causes a complex set of physiological and psychological responses. The drop

in core body temperature that follows prolonged cold stress is gradual and may exacerbate previous performance decrements or create new ones. When core body temperature falls below normal (around 37°C), it can be regarded as a beginning of hypothermia, but hypothermia is generally defined clinically as a core body temperature below 35°C (or about 95°F). The effects of deep body cooling on overt behavior are similar to the effects of general anesthesia. Levels of consciousness and alertness gradually decrease as body temperature drops toward 30°C. Responses become slow and reflexes sluggish; speech becomes slurred and increasingly difficult. Mobility is impaired, and individuals often become drowsy or apathetic. There is some impairment in memory registration, beginning at a core temperature of 36. 7°C and progressing to a point of about 34°C to 35°C, at which 70% of information normally retained is lost [4]. Concentration becomes increasingly impaired, although at early stages of hypothermia (34°C-35°C) the impairment appears to be in the speed of mental operations rather than accuracy. Although lowered body core temperature slows the performance of complex calculation tasks, and reasoning tasks, such slowing is not accompanied by any loss of accuracy-provided that adequate time is allowed for the task to be completed. The slowing observed, however, is substantial with calculations being about 175% slower at a core temperature of 34. 2°C [4]. As the body cools further, casualties of cold stress may become increasingly confused and even incoherent as hypothermia progresses below 34°C to 35°C. Cold stress-induced auditory and visual hallucinations are not uncommon occurrence as core temperature drops below 35°C and are occasionally reported by individuals exercising in the cold as well [5]. Voluntary movements gradually become slower and a simple

movement such as touching the nose (normally accomplished within 1 sec when warm) may take 15 to 30 seconds as the core temperature approaches 30°C. Muscle rigidity, sometimes accompanied by neck stiffness, is often striking at this point, making it difficult to extend the limbs. Gait may become ataxic and deep tendon reflexes may decrease. At a core temperature of 30°C to 31°C the pupils may react so slowly that the light reflex may be wrongly assumed to be absent, although it will essentially disappear at lower temperature [6]. Consciousness is usually lost between 32°C and 30°C, although there are exceptions to this. If temperature continues to drop the individual goes into coma.

Brain and Behaviour

As the core body temperature falls various changes occur in hormonal & melatonin secretions, which lead to changes in brain and affect behavior. These changes have been postulated to occur in three different ways. Firstly, the arterial blood carries cold blood to the brain thereby cooling it, but the venous outflow buffers it to some extent. Secondly, the cerebral blood flow and cerebral metabolic rate for oxygen also diminishes. These changes may vary in different parts of the brain. Thirdly, as the core body temperature falls there is initial excitation of neuronal conduction but progressive slowing of synaptic transmission and its abolition occurs as the core body temperature touches 20°C, whereas axonal conduction stops at temperatures below 10°C [2].

The anterior pituitary hormones, insulin and melatonin secretions are diminished in cold environments. These changes are associated with

changes in Galvanic Skin responses (GSR) to standardized cognitive stress [7]. Brain thyroxine levels diminish despite normal peripheral levels [8]. These changes lead to variations in sleep patterns and levels of arousal leading to various psychological impairments [1, 4]. The mechanism responsible for cold stress induced auditory and visual hallucinations is not clear, although it may relate to dopaminergic super sensitivity. It has been hypothesized that all hallucinations, and other disturbances of perception, involve the dopamine/5-hydroxytryptamine (5-HT) system and are a result of an overload at a rate-limited step in the degradation pathway of 5-HT [5]. There is an excessive production of dopamine. Dopamine release activates dopaminergic receptors, which cause lowering of the body temperature either directly or via intermediate 5-HT receptors. During prolonged exposure to cold, dopamine receptors could therefore become supersensitive. It is possible that at least some of the observed decrements in human performance that occur following prolonged extreme cold stress and during hypothermia may be determined by [6-10] –

(a) Direct or indirect effects of brain cooling,

(b) Changes in brain cerebral blood flow, or

(c) Changes in the electrical activity of the brain.

Animal studies [11] have shown that:

¬ The arterial blood removes heat from the brain during hyperthermia,

¬ Venous blood circulation buffers rapid brain cooling during hypothermia, and

¬ Brain-blood temperature gradients are the major determinants of fluctuation in brain temperature.

Effects of Hypothermia on Cerebral Blood Flow

Though cerebral blood flow (CBF) and cerebral metabolic rate for oxygen (CMRO2) decrease with body temperature, but the sharpest drop in cerebral metabolism occurs with body core temperature reductions down to 28oC, and that further temperature reductions do not produce a correspondingly greater depression of cerebral oxygen utilization. During hypothermia, cerebral vascular resistance increases despite elevated arterial carbon dioxide tensions. This increase may be due to two factors:

(a). Hemoconcentration in response to hypothermia increases blood viscosity and cerebral vascular resistance.

(b). Cerebral vessels may constrict in much the same manner as peripheral vessels in a response to hypothermia.

The reduced CBF and decreased metabolic rate that occurs with profound core body cooling may not allow efficient information processing by hypothermic individuals [12].

Although cold exposure clearly affects vigilance, substantial vigilance decrements are likely to occur only during dynamic shifts in core body temperature and are not likely to occur at steady state temperatures, suggesting that fully acclimatized subjects would be unlikely to exhibit vigilance decrements even at very cold ambient temperatures. Investigations completed thus far suggest (1) minimal decrements in simple

reaction time except in the most extreme conditions, but (2) marked changes are seen in more complex reaction time tasks. The fact that extreme cold stress can induce confusion and impaired consciousness has been known for some time, and a series of studies has examined the effects of both cold-water immersion and pronounced cold stress on memory and memory registration. Decrements have been observed in divers' abilities to recall material learned underwater, impairment in the recall of short paragraphs, and delayed matching to sample visual memory. The available evidence in the area of complex cognitive functioning suggests that decrements in cognitive functioning owing to cold stress are, for the most part, directly related to task complexity.

PSYCHOLOGICAL ASPECTS OF COLD ENVIRONMENT

Exposure to extreme cold environments even when for only brief periods can have longer effect on the body. Thermal perception is the subjective ability to assess the thermal sensation. This has to be differentiated from the feelings of pain and cold discomfort. Pain sensation is lost below 10°C especially when the cooling is rapid. Perception of cold and comfort interacts with perceived level of physical exertion and stress coping mechanisms (13). Arousal is also affected in cold environment. Mild cold stress stimulates arousal to allow for simple tasks to be accomplished, but as the complexity of the task or the cold stressor increases the level of arousal shows diminution. Along with changes in arousal, ability to sustain attention also is diminished [2]. These changes can at times be detrimental to the very survival of the individual. Major changes due to cold environment seen in various psychological functions are discussed below.

Cognition and cold environment

Reduction of core body temperature to hypothermic levels does impair cognitive functions, but moderate non hypothermic cold exposure rather improves it. Probably the faster rate of cooling is more impairing than gradual cooling. One of the theories to explain this is the ‘ distraction theory’ which suggests that the discomfort caused by cold could consume most of the central attentional resources causing a shift from task at hand leading to impaired performance. On the other hand experimental evidence suggests that mild to moderate cold exposure initially leads to improved performance (14).

Cold weather can cause negative mood states especially when individual is exposed to stressful conditions like rigorous training for war and can impair critical task performance and combat preparedness(14, 15 16). Coping skills mechanisms like problem solving and positive reappraisal are likely to be associated with less negative affect whereas emotional control and escape coping skills with more negative affect (17).

Vigilance

Optimum vigilance can be maintained when ambient temperatures are around 27°C-32°C. Any decrease or increase further will only lead to diminution of vigilance. Vigilance is related more to the core body temperature changes than to any changes in comfort level or pain perception. Therefore a well-acclimatized individual is less likely to have any decrement of vigilance [2, 18, 19].

Reaction Time

Investigations reveal that reaction time to simple tasks (as measured under test conditions by ability to recognize 0 when it is intermittently shown while visual presentation of numbers from 1-8 is randomly done) is unaffected by cold weather conditions except in extreme cold weather. However when the complexity of the task increases (like when in the test described above the subject is expected to recognize the odd and even numbers and press the appropriate buttons) there is 200-300% increase in reaction time in addition to increase in errors in the form of increased speed of incorrect responses and number of false alarms. These errors were more related to decrements in skin temperature rather any fall in the core body temperature. Therefore it is postulated that rapid cooling may affect complex reaction time by increasing the discomfort and distraction rather than by any change in core body temperature [2].

Target Tracking

Similar to reaction time the ability to visually track an object is also affected. Movement tracking is significantly affected even at ambient temperatures of 10°C but a complex task involving need for attention towards various controls gets maximally affected at 4°C [2]. This has tremendous military ramifications especially when vigilance and reaction times are also diminished. The soldier’s ability to locate, identify, track and finally neutralize an enemy in cold environment can be severely compromised.

Memory and Recall

Memory impairment following exposure to hypoxic, hypobaric and extremely cold environments is common knowledge. Studies have shown that such impairment is more acute and drastic when cold-water immersion occurs as in deep sea divers. It has further been seen that inability to maintain attention was related to decrements in ability to recall material learned in cold environment, logical reasoning, simple arithmetic, digit span & word recall. Word recognition was directly related to falling core body temperatures [2].

Sleep

The polar conditions in addition to offering extremely cold environment also has periods of very short or prolonged daylight and similar conditions could be found in some of the extremely cold posts of our army. This adversely affects the diurnal rhythm of the body. Some of those unacclimatized to cold, especially women may have only diminished amount of sleep though it is unlikely to lead to any major psychiatric ailment [20]. Among those staying over for winter in Antarctica some have been found to develop significant changes in melatonin levels resulting in disturbances in diurnal rhythm, thereby causing decrements in the psychological well being especially visuo-motor tracking efficiency [9, 20 , 21].

Driving.

Reduction in performance of tasks such as driving can be reduced up to sixteen percent on exposure to cold environment (22). Thermal sensation of cold in the hands can be a significant independent predictor of decreased accuracy and shorter response time (14). Hence, military vehicle drivers who

have to perform in extremely dangerous routes in very cold weather conditions should be provided with ambient temperatures in their cabin.

PSYCHIATRIC EFFECTS OF PROLONGED EXPOSURE TO COLD ENVIRONMENTS

Personnel located in high altitude and extreme cold environments are subjected to a number of stressors that may be grouped into three categories: Isolation, confinement and environment. In winter the stations are physically isolated from the outside world for long periods of time. Separation from family and friends causes varying degrees of emotional deprivation. The individuals are confined to their location for prolonged periods and interact throughout the day with the same set of people. This constant interaction creates a potential for conflict between colleagues, or people with conflicting personalities. Finally the environment itself poses significant stressors, as residents have to contend with high altitude, extreme cold, and low humidity. Physiological responses to these environmental conditions include reduction in Stage III & IV and REM sleep, dyspnoea, arterial hypoxia, headaches, hypocapnia, erythrocytosis, mild alkalosis and suppression of the immune system [23]. Approximately 5% of personnel experience symptoms that fulfill DSM criteria for a psychiatric disorder and are severe enough to warrant intervention [24]. Mood disorders are the most common disorder diagnosed and is significantly associated with female gender. Other common disorders are adjustment disorder, sleep related disorders, and substance use disorders. However there is also a salutogenic outcome in that those who cope successfully with the stress have enhanced self esteem, improved health and personal growth (25, 26). Therefore those with a history of psychiatric disorder, current symptoms of

psychosocial distress, or considered to be at risk for a psychiatric disorder and/or poor performance are disqualified from winter-over duty. There is a significant increase in the prevalence of subsyndromal seasonal affective disorder during winter [27]. A significant inverse association between satisfaction with support and concurrent and prospective measures of depressive symptoms is reported. Pre-deployment level of depressive symptoms was the only significant independent predictor of late winter depressive symptoms [28]. Increased incidence of irritability, anger, transitory visual & auditory hallucinations, tension, anxiety, fatigue and depression are the other common manifestations when there is prolonged exposure to extreme cold weather.[29, 39].

Adaptation to Cold Environment

Ability to adapt to extreme environments is what has made the human species inhabit most of the earth. It is but natural for us to try and understand what it takes to adapt to extreme cold environment also. The process of adaptation essentially consists of physical and psychological aspects. We shall restrict ourselves here with only the latter part.

The initial part of psychological adaptation occurs over the first few days. It involves the lowering of cold perception and pain sensation. Other processes involved are seeking comfortable clothing, avoiding exposure to cold and learning from experience. These are helpful for new comers to a harsh cold environment.

It is interesting to note that personality profile of an individual can to a large extent affect the way he adapts to extreme conditions. There have been

extensive studies in Antarctica on these aspects. Personality factors affect the psychosocial peculiarities of such an environment like cold, isolation, and boredom. It has been found that people, who have high levels of extraversion and conscientiousness, low levels of neuroticisms, do not seek affection from others to feel good and those seek challenging experiences do better in cold environment (31). Further, those who were on a higher hierarchical scale of organization, had more autonomy and had a need for achievement did better. Follow up studies on these subjects on return to their homes found that they continued to do well. Palinkas et al [32] reported that irrespective of all these variables all those who braved the cold of Antarctica felt good on return. It has been found that despite the hardships of living in such extremely cold conditions it was only the positive outcomes that were more frequently reported [33, 34, 35].

In an interesting study by Selvamurthy et al it was reported that practice of Yogasanas and Pranayama for 55 minutes daily for 6 months does produce a change in the physical parameters as well as psychological well being that helps in adapting to cold environment. He has suggested 15 different types of asana such as Padmasana, Matsyasana, Sarvangasana, Chakrasana, and Shavasana to be practiced daily [36]. Prolonged and more rigorous practice of these could help the soldier bear the cold more effectively but he often has to undergo deployment at short notice and train for other duties as well.

PRACTICAL APPLICATIONS AND MILITARY CONSIDERATIONS

The performance decrements following cold exposure that have been demonstrated in controlled laboratory environments have important

implications for personnel in the field as well. In some circumstances, cold-induced decreases in performance can lead to significant impairments in mission critical tasks, putting both cold-affected individual and the group at risk.

 ¬ Impairment in vigilance at extreme cold temperatures suggests the need for much more frequent changes of sentries and sailors on watch if not sheltered from the elements than would be expected in temperate climates. This would also hold true for divers, and suggests the need for shortened dive times in cold-water missions when practical. In like manner, the available evidence of possible decrements in memory recall following cold water immersion suggests the need for either briefer exposure times or the use of written notes taken at the time or direct on-line communication.

 ¬ Those with a history of psychiatric disorders, current symptoms of psychosocial distress, or considered to be at risk for a psychiatric disorder should not be deployed in high altitude extreme cold areas.

Future implications

Improvements in research on working of the brain have revealed that an interoceptive system involving various parts of it may work in cohesion to help adaptation to extreme environments. This includes information provided to systems that monitor value and salience of an event or situation (Orbitofrontal cortex and amygdala), the reward pathways (Ventral striatum and Amygdala), critical areas for cognitive process (Anterior cingulated) and emotional response to environment (Insular Cortex). Further elaboration and

understanding of these substrates may help devise ways to target them to improve performance under extreme environmental conditions (37).

The environs of an extremely cold environment on earth are similar to what you might come across in an inter-planetary sojourn or extended space expedition. Therefore the knowledge gained from studies of cold environment shall benefit in finding the right person, train him in the right manner and finally make the optimum utilization of his expertise without causing any significant long term adverse effects on his well being [38, 39]. Since most of these studies are being carried out in Polar Regions this science is being termed as ‘ Polar Psychology’ [7].

Military application of knowledge from polar psychology will go a long way in harnessing the best out of the soldier even in extremely harsh cold conditions to overcome his adversaries.

Summary

To understand the intricacies of psychological aspects of cold environment we need to know the working of the brain in different temperatures. The changes brought about by exposure to cold environment in the chemical & electrical activity of the brain probably lead a wide spectrum of behavioral changes in humans. These changes are directed towards survival of the individual but some like decrements in vigilance, motivation and attention could be detrimental to his well being. Some of the changes are related to skin temperature and some to core body temperature decrements. The adaptation process is manifold. The psychological symptoms arising and the coping skills learnt during this process could be beneficial even long after

they have returned to ambient temperature environment. Study of this subject now termed as polar psychology shall be instrumental adapting human species into longer and colder inter -planetary travels.