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Original Article

Cognitive deficits due to thermal stress: An exploratory study on soldiers in deserts

Col Rajiv Saini^{a,*}, Kalpana Srivastava^b, Gp Capt Sunil Agrawal^c,
Air Vice Marshal R.C. Das^d

^a Associate Professor, Department of Psychiatry, Armed Forces Medical College, Pune 411040, India

^b Scientist 'G', Dept of Psychiatry, Armed Forces Medical College, Pune 411040, India

^c DMS (Health) & Senior Adviser (Community Medicine), Air HQ, Office of DGMS (Air), New Delhi, India

^d Principal Medical Officer, Eastern Air Command, C/O 99 APO, India

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ABSTRACT

Background: It is well known that environmental factors play an important role in human performance. High temperature and humidity particularly impair mental performance by altering brain neurochemistry and electrolyte disturbance which in turn affect one's overall efficiency. While the physiological responses to environmental heat have been well established, it is less clear about its impact on cognition. Study aims to investigate the impact of thermal strain on cognition.

Methods: One hundred (100) healthy soldiers aged between 20 and 30 years who had spent minimum of one year in desert conditions prior to their induction in the study formed sample of the study. The subjects were evaluated on memory and on cognitive functions twice i.e. in the month of February and June. The data so generated was analyzed by appropriate statistical methods.

Results: The mean age of the subjects were 25.8 yrs. There was a significant decline in cognitive performance in hot climate as compared to normal weather on Post graduate Institute (PGI) memory scale ($P < 0.05$). The effect was more marked for tests requiring sustained attention, concentration, psychomotor performance, verbal memory and tests of executive function.

Conclusion: The present study is the first study to be conducted in actual desert conditions. Findings revealed a detrimental impact of thermal stress on the cognitive performance of soldiers in deserts.

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Introduction

Military service and climatic hardship share a unique relationship. Many key operational zones across the world

are located in places where not only the enemy but weather is equally hostile. However, in spite of these testing conditions, the soldier is expected to perform at optimum levels at all times. Since any compromise of his mental or physical efficiency can lead to dire consequences, it is imperative that

* Corresponding author.

E-mail address: rajiv_100_98@yahoo.com (R. Saini).

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his body and mind remain fit and function in complete harmony.

Effect of high temperature on human behavior in terms of more irritability and decreased efficiency is well known. Studies have also confirmed that thermal stress leads to general physiological hyper-arousal and decline in cognitive performance.¹⁻³ Studies on the effect of exercise under hot and dry conditions suggest that there are significant cognitive decrements under such conditions.⁴ The decline in cognitive performance is more with increase in complexity of the task.⁵ In brief, cognitive decline under thermal strain is positively correlated with severity of heat strain and the complexity of the cognitive task at hand. Plethora of research indicates that high heat and humidity pose significant stress on the cardiovascular system in maintaining homeostasis⁶ though very little research has been conducted to explore the effect of heat on the cognitive performance of soldiers in deserts. The issue gains further importance as so many strategically important areas lie in deserts across the world. Present study aims to investigate the effect of thermal strain on various aspects of cognitive performance of soldiers in deserts.

Material and methods

Sample

Male troops are deployed all along the western Indian border where temperature touches more than 50 °C during summer months. The previous year meteorological data was obtained from the Rajasthan State Meteorological Department (Met Dept) and Corps Headquarters (Corps HQ) Medical Branch located somewhere in the western border region. Sample of the study comprised of the troops deployed along the border in deserts at extremes of temperature. Based on the met data, zones of high temperatures were identified along the border in desert areas. One of the infantry battalion company deployed in that dry arid high temp zone was selected for study. Troops deployed on western border were selected because of its strategic location and higher cognitive demands to maintain vigil and state of readiness. The inclusion criteria used for sample selection was:

- (a) Healthy soldiers aged between 20 and 30 years who had spent minimum of one year in deserts.
- (b) Soldiers who are not likely to be posted out in next 6 months.
- (c) Soldiers with normal or corrected vision and hearing and absence of any psychological morbidity or physical disease.

Same sample was assessed in the month of February and June. Since the study was to be conducted before and after extreme temp conditions, the Commanding Officer was requested to make maximum soldiers available for the study. At the outset of the study, the authors did not have any baseline data available as such kind of study had not been undertaken in Armed Forces context in the past. Adequate hydration was ensured and no amount of physical exertion was permitted while the sample was being tested on

psychological measures. They all had adequate sleep the night prior to cognitive testing. The company had total 136 soldiers and based on our inclusion criteria 107 were selected. However, 7 soldiers were not made available during collection of data in June hence, removed from analysis.

Tools

(a) Sociodemographic and clinical data sheet for recording of age, service, trade, date of induction into deserts, duration of actual time spent in desert conditions (excluding the period of leave/temporary duty), educational qualification, any disability/current medications were recorded.

(b) Psychological tests administered were Post graduate Institute memory scale (PGIMS) also referred here as PGI memory scale, Trail Making test, Reaction timer and Computerized version of Wisconsin Card Sorting Test (WCST). In the PGI memory test, out of 10 subtests, tests of recent memory, remote memory and mental balance test were excluded because they demonstrated a ceiling effect. Trail making test comprises of two parts i.e. A & B. The time taken by the subject for the two sub parts was measured using a stop watch. Three scores were obtained. Time (seconds) taken to complete task A, Time (seconds) taken to complete task B, Trail Shift (time difference i.e. Time B minus Time A). **Reaction time** is a measure of time elapsed between exposure to a sensory stimulus and the subject's response to this stimulus. Reaction timer comprised of equipment wherein the subject was expected to respond to auditory or visual stimuli in the shortest possible time. Ten such readings were taken for each subject and the mean was counted as mean visual reaction time. Responses were measured for both hand and foot for all the subjects. Reaction timer tests audio-visual psychomotor response and is a good measure of its speed and integrity.

Wisconsin card sorting test (WCST) is used to evaluate executive functions especially those involving the frontal lobes. All the psychological instruments are standardized and Indian norms for them are available. These tasks measure a range of cognitive processes including attention, concentration, memory, verbal learning, information processing and executive function.⁷⁻¹⁰

Methods

The study design and the protocol were approved by the institutional ethical committee. The study was conducted during daylight hours in tents in actual desert conditions because they represented the actual conditions in which the soldiers stay and work and no artificial cooling means were allowed. The months of February and June were chosen for the study. The temperature is comfortable 25–28 °C in February and in June it usually crosses 42 °C which was supposed to represent hot weather. 25–28 °C has been found to be most conducive as far as human cognitive functioning is concerned (1). The measure of temperature was obtained using a standardized electronic hygrothermometer and later compared with State Met Dept and Med Br of Corps HQ who maintain temp chart. Subjects were allowed to hydrate themselves with plain water depending on their choice.

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