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Original Article

'Health, Environment and Training': Guidance on conduct of physical exertion in hot and humid climates

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ABSTRACT

Background: Military operations and training in hot environments present a special set of challenges to medical personnel who must support them.

Methods: Various meteorological parameters such as relative humidity (RH), ambient air temperature (Ta) and radiant temperature (Tg), were evaluated at training sites in a desert region. Development of a colour coded Heat Stress Prevention Decision Aid Tool was done using an existing guideline chart.

Results: Temperatures were being recorded routinely by ordinary meteorological instruments mounted within a Stevenson Screen. Onsite measurements with a USB datalogger was found to be relevant in making a decision on suitability of weather for conduct of training. Heat casualties occur when the stresses imposed by some combination of environment, work, and clothing combine to exceed individual tolerance limits. Personnel may encounter high environmental heat loads while working outdoors; during road marches; and while carrying loads or undertaking mechanical maintenance activities. Preventive strategies cannot be expected to eliminate heat stress but should minimize its impact on training while preserving the health of personnel to the extent possible.

Conclusion: It is recommended that onsite measurement of meteorological parameters should be done, and a decision tool should be utilized for arriving at a spot decision by junior leaders.

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Introduction

Since the beginning of warfare, a soldier's environment has had an impact on the outcome of military engagements. History is replete with examples to illustrate adverse weather influenced outcomes, from the Greek wars in Homer's Iliad, from Alexander invading the Asian subcontinent, to Napoleon invading Russia, to Hitler's Russian misadventure in World War II and the experience of the Allies in Burma, to US troops deploying in the Panamas. Thus, lessons learnt are most crucial for a military in achieving an optimal state of 'Force Health Protection' and battle readiness.

Operations by the military under adverse weather conditions, are a challenge to the personnel who provide combat medical support. The environment adversely affects the performance of personnel and also equipment. Wise commanders recognize the requirement of close scrutiny and detailed attention to development of operational plans and execution of military operations in adverse environmental conditions. Warfare in its myriad forms will always be a part of human existence, and as usually there is no choice of 'suitable combat weather', a military has to be prepared at all times – an 'all weather fighting force'. An open-ness in sharing of military research through journal publications has now established a significant wealth of material on human performance in adverse environments.¹

Notwithstanding research, guidelines, consensus statements, etc., operational success in the military realm requires rigorous scrutiny of the intrinsic functional problems of personnel, available health intelligence, training (conditioning) and operational logistics. Accordingly, practical considerations are essential, for Specialists and Administrative level doctors on headquarter staff who are supporting formations deployed to hot weather environments. Military leaders (and those on operational staff) have perforce to acknowledge that—no matter how motivated their soldiers may be—a failure to adopt protective measures and to adapt to adverse environments may result in failure of military operations.¹

There may be an increased risk and higher incidence of heat illnesses associated with training and operations under adverse weather conditions. This may be due to the synergistic effect of physical exertion, environmental heat stress, MOPP (mission oriented protective posture) uniforms and equipment and the demanding circumstances of the field deployment, especially amongst unacclimatized troops. Ideally, military leaders should be aware (at the planning stages) of the various environmental stressors to which their soldiers will be potentially exposed, if effective preventive measures are to be implemented. This is best measured as close as possible to those locations in which the troops will be operating or

training, as the parameters can vary over short periods of time and space and in unpredictable ways.¹

Heat stress indices calculated for a military garrison are non-specific and general guides, as when conditions seem extreme, onsite measurements are essential. Most militaries have adapted the Wet Bulb Globe Temperature (WBGT) Index as the standard metric for environmental heat stress and usually have specific policy guidelines for guidance to military commanders for regulating physical training according to the measured WBGT values. In the Indian Army there is no similar policy or apparatus authorized to either field medical units or fighting units. The various indices available are also mostly theoretical in nature and have not been widely employed. Hence the objectives of our study were primarily to evaluate the various available parameters for convenience in employment using commercially available meteorological equipment, and to develop a user friendly decision aid tool.

Material and methods

Various meteorological parameters such as relative humidity (RH), ambient air temperature (Ta) and radiant temperature (Tg), were evaluated at various training sites in the period from December 2011 to July 2012, thereby covering three identified season paradigms (i.e. cold-dry, hot-dry, hot-humid) in a large garrison in the 'Sun City' (Jodhpur) of Rajasthan. These meteorological parameters were serially logged utilizing portable scientific instruments (Table 1). The timings of measurements were planned to coincide with the timings of training events within the 'Area of Responsibility', which was coordinated through liaison with local units.

The existing guideline chart in a General Staff Pamphlet² on conduct of military training, (also given in the Manual of Health for Armed Forces in its various editions) was adopted as the baseline for evaluation and subsequent customization, as it was beyond the scope of our study to undertake physiological impact measurements.

Results

Temperatures were being recorded routinely for the military garrison by ordinary meteorological instruments mounted within a Stevenson Screen located within the garrison (Tables 2 and 3). Liaison was established with the local airport authorities, for correlation of the data collected and there was found to be no major variation. A decadal trend of the temperature and RH for the season (December to July) is given at Fig. 1.

Table 1 – Instruments for the project.

Instrument	Make	Model	Cost (2011)
USB datalogger	Sierra	EL – USB-2-LCD	Rs. 11,531
WBGT heat stress meter	Sper Scientific	800036	Rs. 18,125
Datalogging area heat stress monitor	Quest	QuesTemp 32	Rs. 420,946
Dry bulb thermometer	IMD Pune	As per IMD specification	Rs. 2825
Wet bulb thermometer			

Table 2 – Meteorological measurements 2006–2012.

		2006	2007	2008	2009	2010	2011	2012
January	Max	31.8	31.4	31.6	29.4	31.5	27.8	25.5
	Mean Max	26	25.7	23.6	38.5	27.3	23	23
	RH	76	66	83	82	80	53	62
February	Max	37	32	34.2	35.2	35.5	34	32.4
	Mean Max	33.3	28.6	26.4	29.8	30.4	28.8	25.9
	RH	70	97	89	71	71	16	62
March	Max	37.3	39.8	39.8	38.6	43.2	38.5	39.2
	Mean Max	32.6	32	36.2	35.2	38.4	34	33
	RH	89	95	69	59	68	27	65
April	Max	42.6	43.6	43.2	44.8	45	45.2	41
	Mean Max	39	40.7	37.7	38.5	42.3	39.3	37.3
	RH	61	81	91	54	60	31	69
May	Max	45	45	41.8	45	48.8	46.6	47
	Mean Max	41.8	41.9	38.9	42.3	44.4	41	41.2
	RH	71	75	82	80	65	85	73
June	Max	45.8	44.8	40.5	42.4	45.6	47.7	44
	Mean Max	40.3	40.3	37.7	40	40.5	45	39.3
	RH	89	88	86	70	71	92	70
July	Max	43	41.6	39.2	44.7	43	40.8	42
	Mean Max	37	35.9	36.1	36.9	38.1	38	37.2
	RH	91	95	93	98	96	91	65
August	Max	38	39.8	37.2	38.8	38	38.8	
	Mean Max	33	34.7	32.6	34.9	34.9	35	
	RH	98	93	95	94	96	86	
September	Max	39.8	40.4	38.2	41	39	35.4	
	Mean Max	35.8	36.5	35.7	38.18	34.8	32.4	
	RH	93	90	93	81	91	86	
October	Max	40.2	37.6	39.4	43	37.8	35.7	
	Mean Max	36.3	36.1	37.3	38.1	35.8	33.5	
	RH	76	66	61	78	78	75	
November	Max	35.6	36.8	36.2	38.5	32.8	31.4	
	Mean Max	32	33.8	32.5	35	29.4	30.5	
	RH	78	58	68	66	78	71	
December	Max	29.8	29	35	36	30	29.8	
	Mean Max	26.1	25.9	28.0	30.6	25.2	26.1	
	RH	75	90	91	65	61	57	

Source: Records of measurement of met data at SHO Jodhpur.

Max = maximum temperature recorded on any day in the month in °C.

Mean Max = monthly mean of the daily maximum temperatures.

RH = Mean of the daily maximum relative humidity in the month in %.

Table 3 – Meteorological measurements during project period [from met measurement instruments in Stevenson Screen at Jodhpur].

Month	Average		
	Temperature in °C		Relative humidity in %
	Max	Min	
December-11	26.11	10.85	56.91
January-12	23.02	7.97	62.36
February-12	25.97	10.88	62.49
March-12	33	16.9	64.75
April-12	37.29	22.3	69.47
May-12	41.2	27.16	73.36
June-12	39.38	28.44	69.67
July-12	37.24	28.62	65.1

Onsite measurements with the USB datalogger were carried out with simultaneous measurements with the other instruments. A graphical representation of the

relevant meteorological parameters as captured by the datalogger and generated through its integrated software is at Fig. 2. The advantage of this USB datalogging device is that it can serially log the parameters of Temperature and RH at user specified time intervals and store them for over a year. This output can be obtained on a computer and utilized for record keeping.

The existing chart for heat strain assessment and decision making in vogue in the Indian Army was customized and colorized for use in the Project (Fig. 3). The standard colors used in the traffic light system were decided upon due to widespread familiarity with the color red indicating 'Stop' or 'Danger', the color yellow indicating 'Proceed with caution' and the color green indicating 'All Clear' or 'Proceed'.

It was intended for the temperature and relative humidity to be plotted on the respective axes on the chart and the meeting point of lines notionally drawn through the two values lying in the respective color zone would indicate the action to be accordingly initiated by the decision maker onsite, without having to take recourse to medical opinion on

Fig. 1 – Decadal trends of relative humidity and mean maximum temperature: Jodhpur (2000–2012) (temperature in °C; Relative Humidity in Percentage).

Fig. 2 – Output from USB datalogger on computer through USB interface. Note: The original output graph from the instrument has been compressed to fit the page.

suitability of weather conditions for conduct of exertional training activities.

The US Navy Flag system chart was not considered for practical application in the Indian Armed Forces milieu because of the requirement of measuring of WBGT. The Humidex was similarly not considered for practical application due to its relatively complicated and technical nature and also the requirement of scientific computation.

Discussion

Heat stress is a factor that has significance in the entire deployment cycle in adverse weather conditions. A discerning military leader in his studies of the history of warfare will recognize that heat casualties have posed a problem throughout. Among many operational reasons, it can be speculated that the failure to implement adequate precautions against heat stress may also have contributed to the decisive outcome of the 1967 Sinai desert conflict. The US armed forces have been experiencing heat casualties regularly, since World War II and this continues to be a problem for their trainee soldiers. Tropical and desert climates both pose hazards to the health of

military personnel who must be prepared at all times to operate under conditions to which they may not be used to.³

Effects of heat resulted in a hospitalization rate of 0.56 cases per 1000 population (Annual Health Report 2014) amongst troops of the Indian Army. The modality of data collection from the large number of hospitals is in itself insufficient to provide the full picture of the effects of heat on troops. Based on anecdotal inputs, there is a large preponderance of cases who are managed as 'effects of heat' both in the inpatient services of military hospitals and in the outpatient department at the Hospitals and by unit level MI Rooms, however these are not reported for various reasons. In our experience, the majority of cases of heat illnesses occur due to or are exacerbated by training activities involving heavy exertion in the summer and monsoon seasons.

Routinely, military units seek medical advice from local medical authorities to ascertain suitability of the weather conditions to conduct training evaluation tests. Military leaders are ground soldiers and need to be empowered to take decisions supported by evidence/facts onsite, whether it is in the conduct of training or in operational situations. Our project was envisaged as a step in that direction, of bringing to the unit level, the onsite decision making capability as pertains

Fig. 3 – Heat stress decision aid chart: Indian armed forces.

to fitness (or conducive situation) of a particular weather condition for conduct of training/evaluation involving heavy physical exertion by troops by realtime input. The purpose of the data logger measuring device is to measure the relevant parameters at the site of the training activity, i.e. real time, using a portable instrument. The other sources of info are not accessible real time, even with the penetrance of Internet based apps. The flaw with the earlier sources of info such as station met data, was that it was delayed in time and distant in geographical location as the Stevenson Screen located in the SHO may be distant from the training area.

The instruments used in our Project were scientific, calibrated and intended for use in onsite realtime environment parameter measurement, to empower the junior leadership to take decisions on suitability for conduct of training. There is no difference in the temperature measurement by these instruments as compared with those in the conventional sources. Further, it is well appreciated that the 'microclimate' of different geographical sub-areas are different at the same point of time, hence the requirement of realistic real time onsite measurement.

Relatively simple preventive measures when implemented conscientiously in military settings, can have a significant impact on heat illness rates,^{3,4} yet these necessary preventive measures are often overlooked during contingency planning. Commanders must be advised by their combat medical planners on the potential for adverse effects of heat. Practical options must be proposed for control of environmental

stressors in operational situations. The development of credible combat medical guidance requires a thorough understanding of hot environments, including knowledge of normal human responses to heat. Adequate instructions exist in the Indian Army on prevention of effects of heat as well as on the conduct of physical efficiency tests in hot weather. Training manuals also mention that these tests should be conducted after a defined period of physical training, and also that these tests should be finished before day temperatures rise. Non-compliance of these instructions are important causes of adverse effects of heat, especially amongst cadets/recruits.

A commentary in The Lancet, on the legal and moral responsibility for heatstroke in the military milieu makes for interesting reading.⁵ It hence devolves upon an enlightened and intellectual military leadership to institute state of art recommendations in tune with global military best practices to minimize the burden of avoidable morbidity due to heat illnesses.⁶

Conclusion

It is suggested that a portable USB datalogger with capability of real-time onsite measurement of air temperature and relative humidity be made available at all major military units for empowering junior leaders with the decision making capability to conduct physical training and evaluation tests in

conducive weather conditions. Medical units may be equipped with suitable WBGT measuring instruments for utilization in providing technical 'medical' advice on suitability of weather conditions for conduct of physical training activities. Proactive implementation of preventive measures will undoubtedly work in favour of minimizing casualties due to environmental heat stress.

Conflict of interest

The authors have none to declare.

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