



ARM IMMERSION COOLING SYSTEM (AICS) FOR MITIGATING HEAT STRESS : LOW ON TECHNOLOGY, HIGH ON DIVIDENDS

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ABSTRACT

Background : Troops are at increased risk of suffering from heat stress during training. Active cooling using external cooling methods is preferred. Arm Immersion Cooling System (AICS) is a novel active cooling gadget, developed the U.S. Army Research Institute of Environmental Medicine. **Methods :** AICS is based on the premise that immersion of extremities in water results in lowering of body temperature. Extremities act as heat sensors owing to their large surface area. The AICS is a portable trough filled with iced water, in which soldiers can immerse their arms. Immersion of arms increases heat extraction more than 20 times as compared to air. **Results :** AICS has been improvised to cut down the weight and improve portability. It has a height of 40 inches and can hold 20 gallons of water. It can be used by six persons at a time. It also has an in-built thermometer and a time table. Best cooling is obtained with water at 10°C. **Conclusion:** AICS is suitable for hot weather with high humidity. It may be placed at strategic locations during training events to prevent heat stress.

KEYWORDS :

During the summer months, the atmospheric temperature and humidity increases in majority of the stations in the Indian scenario; during which period, cases of heat stress are common.¹ The incidence also tends to increase subsequently during the monsoons with a rise in the level of humidity. Troops are at increased risk of suffering from heat stroke and heat exhaustion during daily training in the form of BPET/PPT/Ghatak & related exercises, which involve strenuous physical activity; often in the sun. Protective clothing worn by troops such as bullet proof jackets and patkas (head gear) prevent heat dissipation, thereby increasing the risk.

Conventional practices such as use of water and fans or hand held pankhas to cause cooling by evaporation, ice blocks, water soaked clothing or pouring cold water on the body only give a subjective feeling of getting cooled, but their overall effectivity is low. Cool rooms as sanctioned to peripheral units have logistic issues such as electricity supply. Moreover, they are used only when serious cases of heat effects have already occurred. Passive cooling methods such as removal of protective clothing or resting under shade are effective only at moderate temperatures with low humidity.

Active cooling involving use of external cooling methods to bring down the core temperature is therefore preferred. A new advancement in the domain of active cooling is the Arm Immersion Cooling System (AICS), which has been developed by scientists at the U.S. Army Research Institute of Environmental Medicine.²

What is AICS?

AICS is a unique external heat mitigation method devised to adjust to the training programme of troops in the field. The technique is not new, and has been used by the British Navy as early as the Falkland War for reducing the core temperature in sailors on board. It is based on the premise that immersion of extremities in water results in rapid lowering of the core body temperature. Extremities play a key role in removing excess body heat. They act as heat sensors owing to their large surface area, more vascular tissue and less muscle tissue, thereby getting exposed to a larger volume of water. Water is an effective natural coolant vis-à-vis air at the same temperature as its heat transfer coefficient is about 25 times more than air.³ The fluid state of water allows it to percolate to

each area of the extremity.

AICS is a portable trough filled with iced water, in which soldiers affected by ill effects of heat and high humidity can immerse their arms till the level of the elbow and bring down the core temperature (Fig. 1). Arm immersion is preferred to leg immersion as a matter of convenience, as the discomfort in removing footwear is obviated. Studies have demonstrated that immersion of arms in cold water for a contact time of 10-20 minutes have resulted in a decrease of core temp of 0.7 to 1.6°C in individuals doing strenuous physical activity.⁴

As heat is transferred from the hot arms and the circulating blood to the more cooler water by the processes of convection and conduction, the blood circulating in the arms gets cooled. This cooled blood then flows back to the core to extract additional body heat and reaches the arms again to continue the same cycle. It has been found that immersion of arms increases heat extraction from the body more than 20 times as compared to room air.⁵ Immersion of the arm till the level of elbow allows more heat loss than immersion of the hand only.

The AICS gadget has been improvised over three generations. As the first generation was heavy and bulky, the second generation was made to cut down on the weight and improve portability. The third generation was then built to improve the designing aspects. The presently in vogue third generation AICS is made of light aluminium frame to make it light weight and has foldable legs for portability purposes. The trough is about 1.5 metres in length, 60 cm in width and 10 cm height in folded condition.² When opened and mounted, the AICS stands to a height of 40 inches and can hold about 20 gallons of water when set up. Three persons can use it from a single side; hence it can be used by six persons at a single time.³

AICS combines the benefit of light weight and sturdiness. It can hold on to the pressure exerted by six users, who may lean on to the side of the equipment without damaging it. Even the weight of a lethargic heat stroke patient may be supported by the equipment. It also has a head rest to ensure airway patency in an unconscious heat stroke patient. It also has an in-built thermometer and a time table which gives a rough guide of the time required to immerse the arm to achieve cooling of the body by 1°C.

The cooling action depends on the temperature of the water used; the best results being obtained following use of water at 10°C, as it provides the most effective thermal gradient from the core to the water in the trough. The temperature of water in the trough may fluctuate, depending on the ambient weather conditions, the temperature of water poured and the quantity of ice added to the trough.

Advantages

AICS is highly suitable and effective for hot weather conditions coupled with high humidity as is seen in the plains of Northern and Western India, where a sizeable number of our troops are deployed. It utilises cold water which can be easily prepared using ice, which is authorized to all cool rooms, even in the periphery. As it does not depend on the erratic electric supply, the logistic issue is obviated and it can be used in the remotest of desert areas. The equipment is portable, non-cumbersome and easy to carry during move related to deployment and exercise. As it can be used by six individuals at a time, it saves time and resources.

Limitations

With time and frequency of use, the temperature of water in the trough will rise. Hence, the water requires to be changed over time. Too much ice should not be added to the trough as a short cut method to curtail down the time required for the desired cooling as the same may lead to reflex vasoconstriction. A sensation of hand discomfort may be experienced by some individuals during and post-immersion. However, the same is self limiting. As the equipment is meant for use by multiple soldiers at the same time, any wounds or abrasions received by soldiers using the device may present biosafety issues, especially when the injuries may be small enough to go unnoticed.

Conclusion

AICS can come in as a handy prophylactic measure against heat stress amongst troops working in extremely hot and humid conditions and also during training. AICS may be placed at strategic locations such as half way point of route marches, at drill sessions and at the end of BPET runs. However, the golden preventive strategy of acclimatisation and health education of troops to maintain adequate hydration need not be overemphasised.

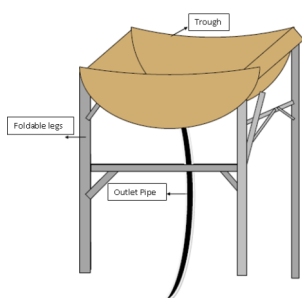


Fig:1 Layout of AICS

Conflicts of Interest

None to declare

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