# Meeting Our First Enemy in the Heat

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Often on deployment we meet our first enemy when we first step off the plane. We sense the temperature is different and the dryness or humidity of the air. If we have been lucky, pre-deployment training made us aware of how different this environment would be compared to our home station, but we cannot truly understand the challenge until we actually feel it the first time.

We can be physically fit as well as optimally trained and supported for the tasks that we face, but our bodies cannot fully adapt to the new situation and attain maximal performance without whole body exposure and the days needed to physiologically respond to the environment's demands. Our bodies always adapt to meet the environment that it is in at that moment. Changing our environment means our bodies will have to go through its changes and sometimes that means, in the worst case, it may take literally weeks before our body's new stability is reached and our supportive behaviors become routine.

The patterns we are concerned with in this article are adapting to a hotter environment that is either dryer or wetter. There are two patterns of heat adaptation — one for desert and altitude dryness, the other for jungle humidity. Each has its special dangers. As tropical animals, it is simpler for us to adapt to excess heat than excess cold. These hotter environments are constantly sucking the water out of our bodies and threatening to overwhelm us with either dehydrating heat or a heat burden. Military operations almost always require that we perform outside our normal healthy body activity parameters, so we must constantly observe and manage the physical demands being imposed on us. The challenge is to learn how to lose heat and moisture to these environments in a manner that we can control and be able to forecast our rates of potential failure.

Any warfighter knows that during a deployment the possibility of having two weeks to allow the body to gently adapt to a new environment is usually pretty small. There are three components to the body's adaptation: nerves, hormones, and behavior. Nerves begin to respond in seconds. Hormones begin to respond in minutes to hours. Behavior acts at several levels and is key to the warfighter's ability to perform. Behavior is based on what we know, how we have been trained, and the awareness and discipline we bring to the task.

### Our Transitions to Heat Acclimatization

The difference in the dangers between dry and humid heat will show very quickly with the perceived heat burden on the body growing more rapidly in humidity. Humidity slows evaporation of sweat so that body heat quickly builds and becomes felt as a burden, while desert dryness speeds up evaporation making the body sense that it is cooling even though the total body's heat load is instead growing. This feeling of comfort can fool us into making potentially lethal errors.

According to a 1958 NASA report, people can live indefinitely in environments that range between roughly 40 and 95 degrees Fahrenheit (F), but only if the latter temperature occurs at no more than 50-percent relative humidity. The maximum temperature moves upward when it's less humid because the lower water content in the air makes it easier to sweat and thus keep cool — or at least seem to.

Sweat evaporation is the only mechanism the human body has to cool itself. Generally, sweating occurs when the ambient air temperature is above 80 degrees F. We also normally sweat where our bodies do not have a local airflow to help evaporation such as our armpits, neck line, waist line, groin, and feet.

Observations have shown that the body's very first physiological changes in response to heat take three days to complete. The body's changes can be complete in 10 days under optimal conditions of steady physical activity, food,

***Soldiers from the 3rd Brigade Combat Team, 1st Armored Division wait for their turn to bound during a squad live-fire exercise on 3 November 2016 at Udari Range near Camp Buehring, Kuwait.***

Photo by SGT Angela Lorden

rest, and fluids in a stable environment of moderately extreme conditions. For a complete response, the usual transition period is expected to be 14 days if the environment is stable and not too extreme.

On first exposure there is then at least a three-day window of real vulnerability where the body is initiating its responses to change where it might be possible for normally sub-lethal stress to seriously compromise the body's ability to adapt well enough and soon enough to protect itself.

Each one of the body's systems and adaptation processes needs time to change. Trying to force the changes by supplying excess dietary water and electrolytes does not speed the process of heat acclimatization. These attempts to hurry the processes actually confound our physiology and may make it worse by creating chemical imbalances that the body must then take additional time to correct. The Army treats about 10 to 20 hyponatremia (low body salt) cases each year where excess water has been consumed to the point of diluting the body's sodium and causing the nervous system to malfunction. At least one Army death has been reported with this cause.

Photo by Ashley Cross

*A student in the Air Assault Course at Fort Benning, GA, drinks water after a run on 14 July 2013.*

Our sweat glands adapt differently during humid and dry heat exposures. Heat acclimatization performed in a hot-humid condition stimulates a greater sweat rate than heat acclimatization in a hot-dry environment. This reflects the lower efficiency of our sweat cooling ability in a humid environment.

Men and women acclimatize equally well. Different body sizes and weights will influence how warfighters respond to heat stresses. Training in a hot-humid environment is more stressful than training in hot-dry conditions because humidity slows heat loss while dry air speeds it up. The bigger and heavier Soldiers will suffer more with heat accumulation as the larger mass generates more heat and slows down its rate of loss. In all cases, heavy warfighters sweat faster than light ones and therefore require more water to erase their deficit of body water. Since our rates of sweating are nearly proportional to the two-thirds power of body weight, 200-pound warfighters sweat approximately 30-percent faster than their 130-pound companions.

Though it accounts for only 20 percent of body heat loss at rest in low temperatures, more than 80 percent of our body heat loss is achieved by sweat evaporation when environmental temperatures exceed 68 degrees F. This ability to sweat is our one key mechanism to surviving in the heat.

If warfighters are performing heavy work in the heat, the critical environmental temperature level above which potentially lethal heatstroke is likely to occur may be as low as 85 to 90 degrees F.

Physical exercise can increase our whole body metabolism and its heat generation by as much as 15 to 20 times the resting rate in healthy young males. But because the body only uses 20 percent of its generated energy to provide useful work, the balance must be dissipated and given off as heat to the environment. If it is not, the core temperature will rise to high levels very early during any physical exertion. The heat that injures and kills warfighters is usually not from the sun but from the physical work they do.

When air and ground temperatures are below 92 degrees F, warfighters can lose heat by radiation to the cooler ground or by convection to the cooler air. In air above 92 degrees, the only way a warfighter can lose heat is by sweating. The human body only takes care of its heat exchanges by using water for evaporative cooling.

Exposure to an air temperature of 110 degrees F necessitates a 25-percent reduction in a warfighter's work output. A body water deficit of 2.5 percent (1.8 liters) requires the same reduction of work output by the average man. If both stresses are experienced at the same time, our productivity will be reduced by a total of 50 percent.

Early investigators found that troops in the desert lost 1 to 3 percent of their body weight before voluntarily beginning to drink and then drank less water than they were losing through sweat; the resulting water deficit was not reversed until after the evening meal. E. F. Adolph and associates named this condition "voluntary dehydration." Some researchers claim that the thirst drive does not kick in until 2 percent of the body weight is lost. The thirst drive appears to be good only for 65-70 percent replacement of the fluid lost (although some researchers claim it's only 50 percent). Measured decrements to mental and physical performance are generally first seen at a 2-percent loss. This can be offset to a certain extent by trained, disciplined, and focused effort, but it is no substitute for water replenishment.

The physiology of the thirst drive is too complex to discuss here, but it is important to note that humans do not rehydrate completely unless they have eaten, and those who drink deionized water also do not rehydrate completely. Some form of nutrients needs to be taken in for us to completely rehydrate.

It is now known that the intensity of exercise, rather than the level of dehydration, is the most important factor determining body temperature during exercise. This is because the generation of body heat can overwhelm the rate of heat loss possible with the volume of water-based plasma available.

Dehydration not only elevates our core temperature responses but also negates the thermoregulatory advantages conferred by high aerobic fitness and heat acclimatization. Heat acclimatization lowers core temperature responses when warfighters have all the water they need. However, when we are dehydrated, similar core temperature responses are observed for both unacclimatized and acclimatized states.

We need to know that when we are fit and acclimatized we can produce up to three liters of sweat in an hour of strenuous exercise under the worst of conditions, but our bodies can only absorb a little over one liter from fluid consumption. As is true with our calories and electrolytes, we cannot replenish fluids at the same rate we deplete them; our body simply cannot absorb as fast as it loses. Evaporative cooling can deplete fluids and electrolytes faster than the body can replenish them. This is why knowledge of these phenomena is essential so that we can set a sustainable operational pace and avoid unnecessary casualties by creating states of exhaustion.

## Differences Between Jungle and Desert Stresses

### *Desert*

First, we hope to know all the environmental factors that will impact us and our operations before a deployment. Then we hope to have the time for appropriate training. Finally, we look to the individual and chain of command. An article published in the November-December 2004 issue of *Infantry* Magazine provides an excellent example of how one unit — the 2nd Brigade Combat Team, 2nd Infantry Division — prepared for desert operations in Kuwait/Iraq in 2004.[1] The planning and preparations conducted in anticipation of the deployment ideally should be emulated by all deploying units. This article does not provide a cookie-cutter plan as every deployment is unique. What is absolutely required, however, is that a unit must understand its home-station environment and what the new environment requires to have the same degree of success on the ground. Only with that foreknowledge — and the discipline to follow through — can plans and procedures be adjusted to fit the deploying unit.

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The heat load created by direct sunlight is significant. The desert sun imposes a thermal stress on man that is two to three times that imposed by the open tropical climate, where clouds often obscure the sun. This can be different than the sun exposure in the deep jungle. The physiological strain due to this stress appears to be proportionately greater in the desert. Warfighters will sweat approximately twice as much in the desert as they will in an open tropical environment because they can lose water more rapidly and have more exposure to the sun. Note also that this is different than warfighters acclimatized to the deep jungle who will generally sweat more than the desert acclimatized because of sweat's poorer cooling efficiency in the deep jungle.

Water is the main weapon against heat injuries. It is essential to remember that the thirst drive is only good for about two-thirds of the water lost through sweat. This explains why fit troops will suddenly drop from heat exhaustion or heatstroke even though they have been able to quench their thirst at will. In the early days at the National Training Center at Fort Irwin, CA, a three-part pattern was seen. First, after three days in garrison, those troops who quenched their thirst with beer and soda collapsed with heat injuries as those drinks dehydrate you and make you feel dull. Second, those troops in the field who drank only enough water to quench their thirst collapsed on the sixth night and seventh morning. Third, those garrison troops who drank only water and only to quench their thirst collapsed on the eighth night and ninth morning.[2] Once this pattern was recognized, an education program was created for the rotating units and the pattern all but disappeared. In addition, commanders saw their sick calls drop by 30 percent. Whenever a unit is exposed to heat stress, there must be command emphasis on an adequate supply and intake of water.

Commanders should consider that they and the rest of the leadership are also subject to heat stress and injuries. Heat and fatigue first affect our thought processes. Unit leaders must not let heat and fatigue reduce the effectiveness of the unit's command and control. All too often during exercises, those in leadership and staff positions are up and going around the clock in the first days until they are exhausted. This then leaves the unit without active and effective leadership and staff functions in the final days of the exercise. In combat, this will reduce the unit's ability to respond to and defeat the continuous activities of the opposing forces.

One of the few consistent markers in our body's decline from dehydration is that when we hit 8-percent dehydration we find ourselves unable to spit. I have found myself at this point several times while operating in the desert and realized that I was then perhaps two to three hours from becoming physically dysfunctional from the heat. Therefore, I had to end the mission and get to a source of water.

Remember, the need for a constant and plentiful water supply to provide a substrate for perspiration can be a great limitation for warfighters in dry heat.

***Jungle***

In the humid tropics, the problems associated with heat are quite different. Solar radiation is less of a problem and temperatures are often lower than in the desert. The major thermoregulatory problem is the high humidity which reduces the effectiveness of evaporative heat loss. Evaporation is not so effective in a hot-humid environment, but since water is usually easily available, prodigious sweating over the entire body surface can maximize possible evaporative cooling without necessarily leading to fatal dehydration.

It is usual for operational and medical records to be incomplete and not to coincide. So it is rare to see how operational facts can contribute to medical realities. One operation in history that clearly indicates the effect of jungle heat on unacclimatized warfighters' physical performance has been pieced together regarding the U.S. Marine experience during Operation Starlite on 18-19 August 1965 in Vietnam.

The daily temperatures in that region of Vietnam that time of year was usually between 105 and 110 degrees F. According to one source, it reached 112 degree-plus heat on 18 August. The battle was initiated by the 3rd Battalion, 3rd Marines and

Photo by SSG Brandon Ames

***A U.S. Army Soldier scans the jungle while pulling security during Jungle Warfare School in Ghana on 4 August 2018.***

2nd Battalion, 4th Marines, both having been in country and in combat some six weeks beforehand.

The Special Landing Force (SLF) — Battalion Landing Team (BLT) 3rd Battalion, 7th Marines which consisted of India, Mike, and Lima companies — was kept shipboard as the Pacific theater reserve. The BLT was alerted from the Philippines on 16 August to take part in Starlite. Each of the companies rostered six officers and 176 enlisted.

In late afternoon of the 18th, the SLF arrived offshore. Lima 3/7, which was on the USS Iwo Jima, was heli-lifted ashore, landing at 1543 on 18 August. Under the operational control of 3/3, it was then dispatched to help India 3/3. Lima 3/7 moved out to contact at 1730 and reached its objective area by 1845. The Marines were equipped with steel helmets, no flak jackets, M-14s and M-79s, two metal 1-quart canteens, and a light marching pack with no blanket roll.

After moving into the attack, Lima 3/7 was ordered to a hilltop to meet up with India 3/3. At 1855, Lima 3/7 reported being delayed due to heat casualties, saying it was stalled in battle, could not move, and needed water. LtCol Joseph Muir of 3/3 Marines went out to Lima 3/7 to bring some order to the situation as Lima had numerous medical evacuations involving leadership (including the company commander). Lima 3/7 then needed assistance from India 3/3 as it was apparently unable to guide itself up to the hilltop position. Approximately 1.5 hours of battle in the sweltering jungle heat had emasculated the unit's functional leadership. The decision was made to return Lima 3/7 to the 3/3 perimeter during the night and place it in reserve; the Lima 3/7 Marines were then led down the hill, holding onto each other's belts in the darkness.

Lima 3/7 suffered four killed in action and 14 wounded in action on 18 August (18/182 = 9.9 percent). The heat casualties were not included in this total. The unit spent the next day sweeping the beach before going into its blocking position by 1500.

While Lima 3/7 was almost immediately in combat, India 3/7 arrived at the 3/3 command post at 1800 on18 August and pulled security, with light fighting during battlefield clean up on 19 August. Mike 3/7 beach landed at approximately midnight on 19 August. It spent that day doing light fighting during the battlefield clean up as well. On 24 August, BLT 3/7 re-embarked as the SLF.

The extreme vulnerability of the human in the first days of acclimatization is graphically portrayed in this example. While 3/3 and 2/4 Marines had been living and operating in country for six weeks, the SLF had no recent exposure. Moving into battle in sweltering jungle heat less than two hours after hitting the beach left these Marines dazed, confused, and exhausted in less than another two hours. The operational demands in the prevalent environmental stresses would have immobilized any unacclimatized military unit.

Even being acclimatized is no guarantee of protection as temperature changes often cannot be forecast. On a jungle reconnaissance, I suddenly became aware of heavy heat oppression and the onset of physical weakness as I began to stagger. I slowed my rate of movement and drank water until the feeling of body stress and weakness was moderated some. On returning to camp that evening, I was told the temperature had jumped 12 degrees that day for some reason to over 108 degrees F.

Relying on assumptions rather than hard facts can also contribute to operational chaos. I observed the rotation of a group of engineering troops from Florida and Alabama while assigned to a task force in Honduras. They said they came from a hot and humid home station so they already knew how to operate in the jungle. What they created was the worst unit record for heat illness/injury and heat stress-related vehicle accidents (collisions and equipment roll overs) of any unit that rotated through the task force that year. The Soldiers and their leadership simply lacked the discipline to listen and adopt the safe behaviors needed for that particular jungle environment.

### Summary

Whenever we move out of the general range of 40 to 95 degrees F, we encounter the situation where we must always consider that the environment is always sucking moisture and energy constantly out of our bodies. Our bodies then become yet just another piece of equipment that we constantly have to monitor so that we can depend on it being capable of what we need it to do when we need it.

With awareness of how our warfighters' bodies work and what they need, along with proper planning and execution, we can move on our objectives and take control rather than only being capable of staggering to the objective and collapsing into an exhausted, vulnerable state.

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### Notes

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