

# HEAT STROKE AND ITS ALLIED CONDITIONS

## Commentary: JE Smith

It is a privilege to be asked to write a commentary on this classic paper, originally published in this journal almost 70 years ago just prior to the outbreak of the Second World War. It is a review of the existing knowledge of heat illness at the time, and a personal account of the author's deployment experience in India and Mesopotamia. Some of the points raised are remarkably resonant in the current era, as so much is once again being learnt in operational environments in the Middle East. It would be easy to point the retrospectroscope in his direction and criticise inaccuracies in his review, but there is more agreement between then and now than may first appear. There have of course been tremendous advances in science since then, and our understanding of the pathophysiology and prevention of heat-related disease has grown. However, the underlying pathophysiology of heatstroke is still a matter of some conjecture [1,2].

To take his points in turn, salt and water depletion were thought to be central to the problem at the time. One of the main points raised by Colonel Nicholls is that when adequately supplied with salt and water in the diet, heat illness is extremely rare, even in the extremes of climate. It has recently been noted that disorders of sodium homeostasis may well contribute to the development of heat illness in patients in Iraq, with a complex interplay of factors contributing to the onset of a more insidious form of heat illness [3]. This is explicitly different to the sudden collapse that affects those who succumb to exertional heatstroke in temperate climates such as the UK.

Infusion of saline was known to be of benefit. This is compatible with current advice on intravenous fluid administration in heat illness [4] and the general advice regarding keeping well hydrated and maintaining salt intake through maintenance of normal diet. The use of salt tablets is not currently in vogue, although this depends somewhat on access to a normal diet. This may not always be possible, if out on patrol in extreme temperatures, when appetite may be suppressed and access to food is limited to ration packs. If maintenance of a normal diet is not possible then some other form of salt replacement may be necessary. Prophylactic measures recommended at the time

include what is essentially a risk assessment of performing exercise in adversely hot conditions, and he recommends gentle exercise to maintain cardiovascular fitness but the avoidance of exercising too strenuously in the heat. The same applies today, although a more formal risk assessment including measurement of the Wet Bulb Globe Temperature Index may take place, and the involvement of command in this risk assessment and decision making is vital. It was recognised then that being an alcoholic was a risk factor for the development of heat illness, but I note Nicholls took a refreshingly pragmatic view that a small amount of alcohol is essential for survival in these environments, to stimulate appetite and help sleep. I am also an admirer of the assertion that getting up too early in the morning is a one-way ticket to heatstroke. I suspect he may even have invented the Sunday routines to which we all look forward while on operational deployment. With regard to treatment, the strip-spray-fan method is extremely well described in this paper, as it is in the most recent guidance [4]. While we would now advocate using warm water in the spray to prevent vasoconstriction and facilitate heat loss [5], the principles have not been lost. I am particularly glad that the iced water enema never caught on.

To sum up, as he would say, there is more in common with the thinking at that time than not. Even though almost 70 years have passed since this paper was published, much of the theory has proven to be remarkably accurate, and there is still no definitive answer to the question of why one soldier may fall over with heat stroke while those around him do not.

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## Heat stroke and its allied conditions

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Lieutenant-Colonel TB Nicholls

THE problem of preventing heat stroke and its allied conditions in tropical countries has always been one of considerable difficulty, especially on active service. Troops have to carry out their duties, often under the most unfavourable conditions, and the measures of prevention usually taken have frequently been in conflict with purely military considerations. The confinement of troops to their barrack rooms for long

hours of boredom must necessarily unfit them for the by no means rare occasions when they might be called out during the height of the hot weather. It is a well-known fact that the men of the Royal Artillery in horsed batteries in India have far fewer cases of heat stroke than the men in the infantry; they work in the stables, thus obtaining a certain amount of exercise, while the infantry are confined to their barrack rooms.

There have been many theories as to the causation of heat stroke; but, until comparatively recently, none of them have explained the conditions, nor, what is more important, have they given us any clue for its prevention. The incidence of the

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effects of heat may be a very serious matter on active service. The following figures from the campaign in Mesopotamia show the extent of the problem [13].

#### Admissions For The Effects Of Heat. Mesopotamia.

1914-15	77-39 per 1,000
1916	51-00 per 1,000
1917	74-40 per 1,000

The writer has always been particularly interested in this subject, and had arrived at certain conclusions set forth some years ago in the following letter written early in 1932. It is printed without alteration and the colloquial tone may be pardoned in a private communication.

### Some Reflections On Heat Stroke.

“Dear —,

“May not the etiology of heat stroke be the loss of salts rather than the presence of toxins? It is not very obvious where these toxins are elaborated. Most cases recover fairly rapidly when given intravenous saline. May this not be due to the salts in the saline rather than the fluid, as most cases have had plenty of fluid before they succumb? Also, the improvement is apparent long before any toxins could possibly be eliminated. The idea of toxins is very old, but no one when challenged to demonstrate them has been able to do so.

“In iron foundries it is the custom to provide salt and water for those tending the furnaces to drink, and this is also done in the stokeholds of ships in the tropics.

“In the Oorgaum Gold Mine a form of heat exhaustion with abdominal cramps used to be very common. The mine is very deep and the temperature is, I believe, 130° F. or thereby. The men are now given salt and water before descending, and this is also given to visitors. Since this has been done, heat exhaustion has been non-existent.

“My theory is that the troops are made to take too much exercise, owing to the superstition that if you exercise till you drop, you are ‘fearfully fit’. The excessive sweating consequent on this reduces the salt content of the serum, and, as the young soldier eats so many sweet cakes, and drinks so much sweet tea, he has no appetite for his dinner, and therefore does not replenish the salt lost during the day.

Last year, in a certain district, there were 40 cases of heat stroke at one station, and only three at mine, one of which had had heat stroke the previous year. The S.M.O. at the former is a real ‘He-Man’ and is mad on exercise, and the troops had a lot of it. Whereas I, not being superstitious, stopped most of it at my station and we had very few cases, although, being only 60 miles apart, the climatic conditions of the two stations were identical.

“The inhabitants of the country, after centuries of experience, do not take violent exercise in the hot weather.

“Though, in an official communication, one would be very chary of recommending beer in these degenerate days, I think it is a pity that ‘Char and Wads’ have taken its place. The tea is stewed for hours till it is nothing more than *infusum acidi tannici*, and the cakes seem to be made of sweetened concrete. This is a most constipating combination, and constipation is the half-way house to heat stroke.

“On the other hand, beer is a gentle laxative, and taken in moderation is, in my opinion, a great help in keeping fit in the hot weather.

“One seldom finds a moderate beer drinker in hospital with heat stroke, though, of course, those who drink it to excess are asking for trouble. perhaps the ‘Canteen Wallah’ who used, in the old days, to put salt in the beer, worked better than he knew.

“I think another contributing cause is a too early réveillé. On

a blazing hot night no one sleeps restfully till about 3.30 a.m., then the bugle goes at 5.30 a.m. and the men are deprived of an extra hour of restful sleep, and start the day tired.

Yours, etc.”

Some time after writing this letter, the writer was posted to Multan, which can safely be described as the hottest station for European troops in India, where for several weeks the maximum shade temperature was 127°F.

The measures outlined above were very successful, no single case occurring among the troops during the whole hot weather.

This record, never previously attained in this station, was, however, spoiled by the writer himself falling a victim to heat exhaustion. This unpleasant experience led to a greater interest, and to a desire to learn more of the condition.

On being transferred to the home establishment, every paper on the subject, that I could trace, was consulted. Since many of these sources of information are not readily available, especially to those serving abroad, it is thought that extracts from some of them might be of interest, especially as they lead to new ideas for the prevention of heat stroke.

The most striking discovery made by recent research work is the condition of electrolytic imbalance of the body fluids, due to the loss of salt by sweating, and to the disturbance of the normal water metabolism. This discovery bears out the conclusions, arrived at several years previous to 1932, of the beneficial results of saline administration.

The first paper to be consulted was the article by Lee [1]. The valuable analytical table of the various forms of the effects of heat and their physiological effects should be read by everyone interested in this subject. He gives a possible explanation of the stimulus to work of the heat-regulating mechanism; this may be activated either by stimulation from the heated skin, carried by afferent nerves, or by a very slight increase in the actual temperature of the blood itself. Further study of the paper suggests that the altered chloride content of the blood may be responsible.

It is found that the excretory activities of the thyroid and adrenal glands are reduced in high temperatures and therefore the whole of the metabolism is lowered; this condition may be compensatory to the tendency to increase metabolism consequent on a hot climate.

The profuse sweating often experienced in the tropics involves a loss of chlorides—since sweat is usually hypertonic. The salty taste of this excretion is well known, and, in extreme conditions, the salt can actually be felt on the skin, when this becomes dry.

The loss of fluid from sweating causes an increased chloride concentration of the serum, and when the sensation of thirst causes the ingestion of large quantities of water, the chloride concentration becomes below normal owing to its consequent dilution. Chloride is then liberated from the body reserves, and this is again lost through sweating.

It will be seen then that continual sweating and drinking may lower the chloride concentration to a dangerously low level. This loss may be further increased if diarrhoea or vomiting is present.

The amount of chloride lost through perspiration may be very large in profuse sweating twice as much salt may be excreted as the ordinary man consumes in all forms per day (Glover [9]). This finding emphasizes the need for the troops taking sufficient salt with their meals. They may not wish to take salt because they have previously eaten cakes to repletion, etc.

Moss [14] found that a thoroughly acclimatized miner working in an experimental hot chamber lost as much as 6½ lb. of weight in an hour when at hard work.

Research lends support to the theory that the loss of salt in the sweat of normal people is not completely balanced, in every case, by the salt ingested in the food and drink of people living an ordinary active life, and having a free choice of food.

Confirmation of this theory is given by Marsh [2] who states that it seems as though the body stocks of sodium chloride of men in the tropics are low at the end of the summer, and that there is a definite lag period before the normal sodium chloride excretion in the urine is resumed.

During the hot weather the amount excreted in the urine is below normal, and it is stated by Lee [1] that the figure should not be below 3 grammes. Marsh [2] further states that the whole blood chloride as estimated in fifty persons was :-

Actual mean	404.12 mg./100 c.c.
Standard deviation	38.08 mg./100 c.c.

Whereas in a case of prodromal heat stroke the whole blood chloride was only 263.000 mg./100 c.c.

It is well known that the cessation of sweating and polyuria are frequent warning signs of heat stroke. The former symptom may be caused (Marsh [7]) by the sweat glands being unable to function when the blood chloride is low; it is also possible that there may be a secondary shrinkage of blood volume caused by the loss of fluid, which may also inhibit the action of the sweat glands.

As regards the polyuria: if when a man has a low blood-salt and his body reserve has been so depleted that he drinks thirstily, the tonicity of the blood and body fluids is altered and the body has to deal with the fluid which is excreted by the kidneys, hence the polyuria. By a quick burst of sweating more salt is lost and so a vicious circle is established which can only be broken by the ingestion of salt.

This condition of hypertonicity is termed water poisoning by Moss [14] and Haldane [11].

Lee [1] defines electrolyte imbalance on empirical grounds as a lowering of the serum chloride concentration to 100 m. equ. (mille equivalent) per litre, or 365 mg./100 c.c. or less. This should be compared with Marsh's [2] normal figures for plasma chloride, actual mean 564.08 mg./100 c.c., standard deviation 37.3 mg./100 c.c.

The connection between loss of blood chloride and the onset of muscular cramps has been well established. Cramps comparable to heat cramps are caused by cholera—here again chloride is lost. The forearm flexors and the calf muscles are the most frequently affected, and the abdominal muscles are often involved. The pain may be excruciating, as was the case in the writer's attack.

During the hot weather one frequently finds men reporting sick with vague abdominal pains. These may be very severe, and, in one case, simulated appendicitis. A diagnosis of "colic," "intestinal toxæmia," and so forth may be made, as the symptoms are so indefinite. The author's case was, in fact, diagnosed gastritis at first. These cases may well be prodromal heat stroke, and should be treated as such, as the administration of purgatives would only make matters worse.

This may be the explanation of the puzzling cases of heat stroke that occasionally arise in hospital, when the patient has been resting in bed in a comparatively cool hospital ward for several days.

Muscular cramps in heat stroke respond immediately to the injection of saline—hypertonic for choice. Lee [1] states that glucose is without effect and that sodium bicarbonate may be dangerous. On the other hand, Squadron Leader Morion [8] recommends the administration of 1 to 1½ pints of 2 per cent sodium bicarbonate in saline, and describes the relief as dramatic.

The writer has used bicarbonate and normal saline in several

cases without any ill-effects.

In addition, glucose and bicarbonate as a drink are efficacious—the bicarbonate presumably being converted by gastric hydrochloric acid into chloride in the body.

Equally good results are obtained by the administration of sodium citrate or cream of tartar. The writer has used "potus imperialis" with the addition of 1 to 2 grains of sodium chloride per ounce as a palatable and useful drink in these cases. This mixture may, in addition, be used as a prophylactic.

Another condition associated with heat stroke is a degree of circulatory insufficiency. The dilatation of the skin capillaries caused by the height of the surrounding temperature increases the capacity of the circulatory system. This can be compensated to a certain extent; but if further vaso-dilatation occurs, or the blood-volume is depleted by excessive dehydration, impairment of the circulatory system follows, with such symptoms as fainting, collapse, nausea, vomiting, respiratory disturbance, fatigue and exhaustion in severer cases.

The most frequent exciting causes of these conditions are heavy meals, injudicious use of alcohol, heavy exercise, especially under the stimulus of competition, continued standing, and emotional disturbance (Lee [1]). The milder cases can be treated by routine measures, but those more severe will require an addition to the depleted blood-volume by the injection of saline intravenously.

Marsh [2] makes some interesting speculations on a case of heat stroke associated with a glycosuria. He was of the opinion that the hypochloraemia and the reduction of blood-volume so often associated with diabetic coma were not in this case due to diabetes which existed only as a mild complication and sequela. He further remarked that in cases of experimental heat stroke in rabbits, the high blood-sugar recorded causes him to wonder whether prodromal or fully-developed heat stroke may not be a starting point, hitherto unrecognized, for diabetes.

## Superdehydration.

Lee [1] defines this as a loss of water from the body to such an extent that continued existence is threatened should replacement not occur.

The critical level lies at about 20 to 25 per cent of the body weight. This means that if the body weight is 120 pounds this level is reached by the loss of 3 gallons of water, taking 25 per cent as the lowest survival level.

The normal water loss of a series of inmates of an Institution was investigated by Magee [3]. The average was found to be 5.07 pints in a temperate climate with no hard physical work. Leiean [15] showed that for each 7½ miles march in a temperate climate a loss of 2 pints of water occurred. After a further 7½ miles, with a total loss of 4 pints, slight inefficiency occurred, and after a third distance of 7½ miles with a loss of 6 pints, marked inefficiency resulted, and after a total of 30 miles the danger level would be reached after the loss of 8 pints, if the water was not replaced.

Therefore in a 22 mile march in a temperate country, the total loss would be 5.07 pints (Magee [3]) and 6 pints (Leiean [15]), a total of roughly 12 pints or half the loss of 25 per cent above mentioned.

These figures are, of course, only approximate; but they are of interest in showing that the water needs of troops are much larger than might be imagined, and the necessity of adequate replacement of water losses, if they are to carry out hard work without the loss of efficiency.

These requirements are of course much higher in tropical countries. Dill, Bock, Edwards and Kennedy [4] found that men working in hot mills required 5 litres (9 pints) of water in eight hours. Of this intake, only 7 per cent was excreted by the kidneys.

As eight hours is approximately the time required to march 22 miles, it will be seen that in such a march in a hot climate the water requirements would be of the nature of 9 pints as opposed to the 6 pints necessary in a temperate climate.

If we assume, for the sake of comparison, that the normal resting water loss will be 50 per cent above that requisite in a cool climate, we arrive at the figure of 18 pints required for hard work in the tropics, i.e. 75 per cent of the amount of water loss required to produce the critical level at 25 per cent total loss—the intake and excretion of water being much the same. It is admitted that this can only be a rough estimate, but it will serve as an illustration.

Dehydration, when established, is one of the contributory causes of circulatory insufficiency. As the process progresses symptoms become increasingly apparent, and, later, still more serious results will ensue. Muscular power, circulatory efficiency and alimentary functions are all primarily affected. The impairment of the circulation leads to disordered metabolism, disordered nervous function, and diminished heat loss. Disordered metabolism, in turn, leads to acidemia, which further affects the nervous system, which again may be aggravated by the rise of temperature. The nervous disturbance becomes increasingly manifest and finally leads to coma and to death. The treatment is to restore the lost fluids by injection of saline as well as by ingestion.

## Hyperpyrexia.

This condition is so well known that no detailed discussion is necessary beyond stating that it does not respond to saline administration, and is best combated by the absorption of the latent heat by evaporation of water from the skin.

Leonard Hill [16] points out that the evaporation of water at body temperature carries with it 0.59 calorie per gramme, whereas the melting of ice takes away only 0.08 calorie.

Moreover, 70 grammes of water evaporated from the skin take away as much heat as the use of 1,000 grammes of iced water as an enema.

The evaporation is best carried out by placing the patient on a string bed, or on a metal bed covered with permeable matting, so that moving air can have access to all parts of the body surface.

Cold water should then be sprayed on the patient and currents of air from a fan or fans should be directed on to the moistened body.

Collapse must be guarded against, and the treatment stopped when the temperature drops to 102°F.

## Prophylaxis.

The views as to the mechanism of heat stroke, discussed above, give us the necessary information to enable us to institute our preventive measures on scientific and practical lines.

The deleterious effects of great heat have been recognized for years in many civil occupations, such as those of stokers, blast-furnace attendants, tin-plate workers, and those in hot rolling mills and the like.

These workers have their own methods of dealing with such conditions, many of which are based, all unwittingly, on sound considerations and on the results of practical experience. Some of these methods are equally applicable to military personnel and are worthy of our consideration. For example, it has long been the custom for stokers, who may suffer from the effects of heat, particularly in the Red Sea, to take copious draughts of sea water as a remedy, and in many cases as a prophylactic, thus dealing with the loss of salt and of water at the same time. They are also hosed down with water, and stand under the stokehold ventilators to reduce their temperatures.

Dill, Bock, Edwards and Kennedy [4] report that men

working in hot mills took from 0.04 per cent of salt in their drinking water in winter to 0.1 per cent in the summer and that they consumed 9 pints of this mixture in eight hours work.

The result was that all serious cases of heat exhaustion and cramp were avoided, whereas before the institution of this measure as many as twelve cases were put to bed in one day.

Miners working in deep mines where the temperature is high are also liable to suffer from the effects of heat which are known to them as “miner’s cramp,” “heat cramp,” or “the bends.” These are prevented by the drinking of salt and water as in the case of the Oogram Gold Mines mentioned previously.

McCord and Terenbaugh [10] discuss fatigue in soldiers due to chloride loss and suggest that 0.5 per cent sodium chloride in water as a drink would lessen fatigue and prevent heat exhaustion and cramps.

Starkov and Jikesh [5] recommend aerated water with the addition of 0.5 per cent salt, and Kofoed [6] also administers salt drinks.

Glover [9] finds that workers in hot industries are frequently reluctant to drink salt water owing to the unpleasant taste. He therefore recommends the use of compressed tablets of sodium chloride, each containing 16 grains, which are obtainable from small automatic machines installed in the works.

The workmen swallow one tablet each time they take a draught of water, which may be two or three times in an hour. No ill effects were noted from this large ingestion of salt.

In a certain chemical works, known to the writer, the men add small quantities of hydrochloric acid to the water which they say makes a more palatable draught than the admixture of salt. This is not to be recommended, as the equally necessary sodium is thus omitted.

A very pleasant drink can be made by the addition of salt, either 1 to 2 grains per ounce, as may be necessary, to the ordinary potus imperialis, which can then be aerated if desired in a “sparklet” syphon. The taste of the salt is almost completely disguised, and the aerated variety can be used as a diluent for spirits.

From a practical point of view the two main desiderata for the prevention of heat stroke are an ample supply of water and a sufficient ingestion of sodium chloride. The former presents no difficulty, but, at present, no facilities exist in the Army for the administration of salt, which, in view of the high figures of saline excretion given above, is very necessary.

As a minor measure troops should have their main meal, their meat ration with its accompanying salt, in the evening, when they are most likely to eat it. The sale of tea and cakes should be prohibited for at least two hours before this meal, so that their appetite may not be already satiated by this time.

One of Glover’s [9] automatic machines in each barrack room, adjacent to the drinking water supply, would seem to be the most efficient and inexpensive method of ensuring a sufficient consumption of salt.

Constipation should be avoided, but the use of strong purgatives or large doses is to be deprecated owing to the further depletion of salt during purgation. For this reason the treatment of dysentery with magnesium and sodium sulphates should be watched in very hot weather.

If, however, it is found that large numbers of men are constipated, a useful measure is to administer a small dose of magnesium sulphate under regimental arrangements in the troops’ own lines each Sunday morning after Church Parade. This is usually a popular measure as it saves a walk to the hospital.

We now come to a very vexed question, that of exercise, which, in the right time and of the right sort, is essential to preserve bodily fitness. The beneficial effects of sanely-regulated exercise are so obvious that the unthinking are led to regard it as a panacea for all things at all times.

Any white man in the tropics has only a certain amount of energy at his disposal. If he dissipates all of this in too strenuous exercise he will have nothing left with which to fight the results of the unfavourable climate in which he is situated.

The most incredibly foolish exhibitions of the exercise complex are frequently to be seen. One soldier, a boxer wishing to reduce his weight, was seen running for five miles clad in a singlet, two woollen cardigans and no head covering at 3 o'clock in the afternoon when the shade temperature was 118° F. He was quite unable to understand why he was peremptorily ordered back to his room, or why he was punished next day.

Two young officers complained of feeling faint after playing squash in an uncovered court, the temperature in which was found to be 125°F. owing to radiation from walls exposed all day to the sun.

Again, one sees four elderly men playing four or five sets of hard tennis in the height of the hot weather. The incipient cyanosis of their lips betrays the strain which their circulation has, with difficulty, dealt. Only the administration of what the old-fashioned doctor would call "diffusible stimulant" will restore their colour to normal again.

The men as a whole are frequently exercised far too strenuously in the hot weather, partly as a relief from their day-long incarceration in their barrack rooms, and partly in the hope that it will render them fitter and enable them to resist more effectively the effects of the climate. The fact is, however, that the profuse sweating after strenuous exercise following upon the sweating of a whole day is but paving the way to collapse when the temperature is high.

The native inhabitant of a hot country, after centuries of experience, retires to his house during the heat of the day, and avoids exertion as much as possible. The zemindar and the coolie alike do no work at this time, and only "mad dogs and Englishmen go out in the midday sun."

A frequent cause of collapse is standing for long periods (Lee [1]). It is well known that any lengthy ceremonial parade in the hot weather will always provide the odd case of heat stroke.

A dramatic instance was the collapse of three men on the railway platform at Jhansi at midnight. The temperature and moisture were high - the men had been standing about for several hours and were rather excited at the prospect of leaving a hot and dusty station for the green and cool of the hills.

While an alcoholic person is notoriously predisposed to heat stroke, a strictly moderate use of alcohol would appear to be almost a necessity for the white man in the tropics, if only to give him an appetite, often otherwise lacking, for his evening meal, also to mitigate to some extent the boredom of the long hot day, to assist him to ingest sufficient fluid to replace that lost during the heat of the day, and finally to help him to sleep under what may be very trying conditions.

Sleep is a most important factor in the avoidance of heat stroke. When the temperature is high at night—in some cases it does not drop below 105°F. sleep is difficult, and it is only in the early hours of the morning that restful slumber can be obtained. This is shattered by a too early reveille, and the men are deprived of the better part of an hour's comfortable sleep in the comparative cool of the dawn.

By early reveille and early return to barracks it is hoped that all out-door work will be completed before 10 a.m. The wisdom of this is open to question. The practice of keeping men confined in darkened barrack rooms for long hours appears to be unnecessary if the precautions outlined above are taken.

If workmen can toil for long hours near blast furnaces in tin-plate works, in hot mills, or deep underground, performing the most strenuous work with no serious casualties, it would seem that soldiers, who ought to be in better physical condition, should be able to withstand the not very different temperatures

of the tropics.

If, in an emergency, they have to be called out in the hot weather, they are less able to withstand the heat, not having been exposed to the sun. The mental effect of such a day-long confinement cannot be good for anyone, and mental depression may explain the occasional "running amok" of the men.

There is little for the men to do in their rooms but sleep. Hours of lying in bed certainly do not conduce either to physical fitness or to mental alertness.

It is to be noted that, on most days, officers in India have to remain in their offices until the period of maximum heat, and appear to suffer no inconvenience by returning home to tiffin, not infrequently on a bicycle. Medical officers in particular are often called out in the afternoon, the hottest time of the day, to attend emergencies, from which duties no one seems to have suffered any ill-effects.

Many of us, too, can remember with pleasure long hours of tramping in the jungle on "shikar." No one was any the worse for this.

It may be thought that these last paragraphs are contradictory to the previous remarks on exercise. Gentle and reasonable exercise can do no damage, but when it is pursued to the point of excessive perspiration and of strain to the circulatory system then a caveat should be entered.

To sum up. Nothing very original is claimed for this contribution, but as the literature on this interesting and not always fully understood subject is not readily available, particularly to those serving abroad, it is hoped that this account may assist those stationed in the tropics to realize that the last word has not been said, and that there is much scope for original research to extend the boundaries of our knowledge.

With this end in view, the papers in the bibliography have been quoted fairly freely. The writer, therefore, desires to express his acknowledgment to those from whom he has obtained much of his information.

**Editors note: The idiosyncratic referencing of this article is an exact reproduction of that used by the author in 1939**

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