Heat illness in the army in Cyprus

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Heat illness in the British Armed Forces is a significant occupational risk. This paper analyzes reports of heat casualties occurring in Episkopi, Cyprus from January 1990 through December 1994. A total of 96 casualties were reported from 48 separate incidents. On seven occasions, three or more casualties occurred concurrently (maximum 19). There were 20 incidents causing 32 casualties from Cyprus-based units and 28 incidents causing 64 casualties from units visiting Cyprus. There was a clear seasonal variation of reports with the maximum number of reports occurring from May to August. The majority of reported casualties occurred when the Wet Bulb Globe Temperature was between 26°C and 29°C. Cyprus-based units had most casualties occurring as a consequence of forced marching whereas most casualties from visiting units occurred during military field exercise training. Visiting Territorial Army units had the highest incidence of heat casualties for visiting units. The majority of heat casualties were mild; there were only ten severe cases. It was not possible to identify any particular risk factors applicable to individuals except incomplete acclimatization. The study showed that the current guidelines used by the British Armed Forces do not prevent all heat casualties. It is not possible to estimate how many casualties are prevented by the guidelines. All incidents involving a serious casualty or multiple casualties should be investigated to determine whether the guidelines should be further amended.

Key words: Armed Forces; Cyprus; heat illness; Wet Bulb Globe Temperature.

INTRODUCTION

A review of hospital records of military personnel for the period 1981–1991 showed an average of 135 servicemen and women admitted to hospital each year for heat-related conditions.1 There were 11 deaths during this time. There have been many anecdotal reports of heat illness in British servicemen2–12 during the 1980s. This led to correspondence in the medical literature regarding culpability for the development of heat illness in soldiers.13–15

A soldier who becomes a heat-related casualty is unable to perform his military duty. This loss of man-power might have a significant effect on the military commander’s ability to conduct operations. Thus it is important for a military commander to be able to predict the effects of heat on his troops. Intensive preventive education to reduce the risk of heat casualties was undertaken by all members of the military coalition forces deployed to the Persian Gulf in 1991. One of the factors that influenced the timing of the military operation to recapture Kuwait was the decrement in military performance that would have occurred if the operation was to have been undertaken during the summer. In the end the ground war occurred during a period of unseasonably bad weather which completely abolished the risk of heat casualties.

Heat illness may be fatal. Even if the episode is not fatal there may be severe damage to the brain, liver or kidneys. Less severely affected individuals usually recover quickly with prompt cooling and rehydration measures. However there is evidence for a prolonged period of heat intolerance after the injury.16 Therefore a soldier who sustains an episode of heat illness should have his medical categorization reviewed. Severely affected individuals probably should never be exposed to high environmental or metabolic heat loads in the future. This requires a permanent change in medical categorization which will affect his or her long-term career prospects in the armed services. Moderately affected individuals are likely to be intolerant of heat for a variable period after the incident and so should avoid heat exposure for a period between 3 months.
Table 1. WBGT guidelines in Cyprus

<table>
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<tr>
<th>WBGT Index</th>
<th>Acclimatized</th>
<th>Unacclimatized</th>
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| Below 26°C (white) | Work—normal  
               | Sport—normal  
               | This does not mean heat illness cannot occur. |
| 26°C (green) | Work—normal  
               | Sport—normal  
               | This does not mean heat illness cannot occur. |
| 29°C (green alpha) | Normal work, but discretion in planning heavy exercise.  
                     | Periods of strenuous exercise should not exceed 30 minutes with a rest period of 1 hour for cooling and rehydration. Avoid standard Combat Fitness Tests (Army). Sport may be undertaken with discretion.  
                     | Regular rehydration. |
| 31°C (amber) | No strenuous exercise. Limited activity for hardened troops (12 weeks or more of training in heat). Supervised rests and rehydration for 10 minutes every hour.  
               | Sport—organized sport with discretion and only after medical advice. |
| >32°C | All outdoor training, strenuous activity, and non-essential duty should be halted for all personnel.  
       | Sport—no organized sport. Voluntary sport should only take place after medical advice. |

and 1 year after the incident. Mild cases will require a period of recovery that will prevent them performing full military activities for approximately 2 weeks. The time limits discussed are not supported by rigorous scientific evidence because relevant research has not been undertaken. Overall it can be seen that a single episode of heat illness in a serviceman may have significant effects on his or her future employment.

The basis of this paper is a prospective study of heat casualties reported amongst British Army personnel serving in Episkopi, Cyprus. In spite of the significance of heat illness in the armed forces there are very few published papers relating to the epidemiology of heat illness this occupational group.

STUDY DESIGN

Setting

There are approximately 3,000 British Forces personnel serving in Southern Cyprus. They are based in two separate areas designated Sovereign Base Areas. One is on the Eastern side of the island, the other on the Western side. Within the Western Sovereign Base Area there are two garrisons; Episkopi which houses primarily army personnel and RAF Akrotiri which, as the name suggests, houses Royal Air Force personnel. The Episkopi garrison has a single medical practice, the Garrison Medical Centre, which provides primary care to all UK military personnel living in Episkopi. The majority of service personnel from Episkopi belong to the resident infantry battalion which has a strength of approximately 650 soldiers. This unit conducts military training throughout the year. This training includes a continual programme of physical exercise. However it is extremely unusual for the entire unit to conduct military training simultaneously, thus the number actually at risk of developing heat illness may vary from as few as 20 soldiers (on an organized run) to a maximum of 650 (on field exercise training). During the period of this study the resident battalion changed in September 1992. The remainder of the resident military personnel in Episkopi belong to the headquarters staff. This is essentially sedentary work; any physical exercise taken by these soldiers will usually be on a voluntary basis. Thus headquarters staff are not at significant risk of heat illness.

In addition to the resident military personnel there is a programme of visits from the UK-based units to conduct military training in a hot climate. These exercises usually last 3–4 weeks. These units may either come from the Regular Army or from the Territorial Army (TA). Regular Army units are expected to have the same average fitness level as the infantry battalions resident in Cyprus, so the only significant difference between these two groups is the level of acclimatization. Territorial Army units have a far wider range of fitness levels compared to Regular Army units. Thus there are essentially three groups of soldiers exposed to the risk of heat illness in Episkopi, those from the resident battalion who should be acclimatized to the heat and who are familiar with the conditions, those from Regular Army visiting units who are not acclimatized, and finally those from Territorial Army visiting units who are both unacclimatized and relatively unfit compared.
Table 2. Clinical grading system

<table>
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<tr>
<th>Level</th>
<th>Description</th>
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<tr>
<td>Mild</td>
<td>First Aid treatment only, no admission to hospital, monitoring only</td>
</tr>
<tr>
<td>Moderate</td>
<td>Any admission, IV infusion</td>
</tr>
<tr>
<td>Severe</td>
<td>Admission longer than 24 hours</td>
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to the other two groups.

Detailed medical policy instructions for the prevention of heat casualties in Cyprus were introduced in 1988 and revised in 1994. These correspond to the Defence Council Instruction issued in 1990 and distributed service-wide. The guidelines review basic thermal physiology, discuss individual risk factors and summarize first aid measures. The environmental temperature is assessed using the Wet Bulb Globe Temperature (WBGT). This is calculated using the following formula: 0.7 natural wet-bulb temperature + 0.2 globe temperature + 0.1 dry-bulb temperature. The instructions for physical activity related to the WBGT are reproduced in Table 1.

A system for reporting heat casualties occurring amongst British service personnel serving in Cyprus was introduced in August 1989. This requires the completion of a proforma by the doctor first treating the heat casualty. The proforma is then sent to the Senior Medical Officer at Headquarters, British Forces Cyprus. A copy of the proforma is also sent to the Joint Service Health Unit at RAF Akrotiri.

These forms were designed for administrative purposes and were not designed specifically for research. The proforma identifies the individual and the parent military unit. The time of onset of the heat illness, time of arrival for medical care, and first aid treatment administered are recorded. The nature, duration and location of the activity are noted as are any identified predisposing factors. A grading system is used to estimate the severity of the heat illness (Table 2). The WBGT at the time of the incident is also recorded.

This study analyses all the reports from Episkopi Garrison for the period 1990–1994. The reports for 1990–1992 inclusive were gathered prior to the start of this study and thus the reliability of reporting cannot be determined. However the reports for 1993 and 1994 were gathered prospectively and thus these are known to be accurate.

In all cases the records held by the Senior Medical Officer at Headquarters, British Forces Cyprus and the records held at the Joint Services Health Unit were cross-checked to ensure that all reported cases were included in the study. Meteorological data were recorded at the time of arrival of the casualty at Episkopi Medical Centre using a Metrosonics hs360 WBGT meter for the majority of cases. In the few cases where there was no WBGT value, recorded data was sought from the meteorological office at RAF Akrotiri.

Part of this study attempts to identify the incidence of heat casualties amongst units visiting Cyprus for military exercises. Details of the number of soldiers involved in these exercises was obtained from the Operations/Training Branch at Headquarters, British Forces Cyprus.

The WBGT is reported at 0700, 0900, 1200, 1300, 1500 hours daily between May and October. The WBGT is not routinely recorded outside these months because the average temperature is below the 26°C minimum threshold for the WBGT guidelines for exercise. The 1200 reading for 1990–1994 has been included in this analysis to identify meteorological trends.

RESULTS

Distribution of heat casualties

A total of 96 casualties were reported from 48 separate incidents. It was not possible to determine the incidence (numbers of cases per person at risk) as the total population at risk could not be measured. There were seven occasions when there were three or more casualties occurring concurrently (maximum 19 casualties). The main comparisons were performed by incident (an occasion causing a heat casualty) to avoid the skewed bias that would be caused by comparisons based on the number of casualties.

The bar chart at Figure 1 shows the yearly distribution of heat incidents. The initial yearly decline from 1990–1992 has been reversed with increases in reports in both 1993 and 1994. In this analysis the results were divided into Cyprus-based units and visiting units. There were 20 incidents causing 32 casualties from Cyprus-based units and 28 incidents causing 64 casualties from visiting units. The predominant cause of the increase in reports in 1994 was an increase in incidents from visiting units.

Figure 2 shows the overall distribution of heat incidents per month and the breakdown for Cyprus-based units and visiting units. Although heat casualties can occur throughout the year, the majority of incidents predictably occur in the summer months. This is most marked for visiting unit incidents which had no reported casualties for the winter months October–
March in spite of units being deployed to Cyprus during these months. This suggests that environmental heat load is a more important factor in heat incidents for visiting units than for Cyprus based units.

Environmental temperature

Figure 2 also shows the average monthly WBGT recorded at midday at Episkopi overlaid onto the monthly distribution of incidents. As expected the majority of incidents occur during the summer months when the temperature is highest. There is no clear correlation between number of incidents and environmental temperature. The total numbers are too small to satisfactorily interpret this.

The WBGT readings recorded at 12:00 at Episkopi for 1990–1994 are analyzed in Figure 3. The daily and monthly averages are shown. The wide daily variation is evident but the average monthly figures confirm the expected monthly distribution. Thus, although it is possible to predict the average temperature in a month the wide daily variation means that commanders must allow for additional restrictions to be imposed on their plans because of the heat. Note also that the average WBGT at midday is above 26°C from June to October and that this has significant implications for planning training for visiting units if the preventive guidelines are to be followed.

The WBGT guidelines are in force for at least part of the day for each of the summer months. Military exercises are usually planned several days in advance and consideration should be given to the risks/benefits of training in the heat when the guidelines are likely to be in force.

The distribution of recorded WBGT for each incident per year is shown in Figure 4. The average WBGT for all incidents is 26.4°C, for Cyprus-based units the average is 28.4°C and for visiting units it is 26.4°C. The maximum, average and minimum recorded WBGT measurements for each year are shown in the Figure. There was no discernible trend. However this shows that incidents are still occurring at temperatures when the WBGT guidelines are in force. The chart also highlights the imprecision of the guidelines by demonstrating that casualties occur when the WBGT is substantially below the level at which the guidelines come into operation (26°C).

The number of incidents that occur at each cut-off level given in the guidelines is shown at Figure 5. This also demonstrates that a significant number of incidents occur at WBGT levels below the lowest cutoff level (26°C). The interpretation of the distribution of
the remainder of the cases is less easy. The numbers exposed at higher temperatures will be reduced because higher temperatures are less frequent than lower temperatures. Thus it is not possible to determine the risk associated with the environmental temperature.

The WBGT readings are taken at the Garrison Medical Centre and may not represent the true conditions to which the casualty has been exposed. A limited survey was performed comparing the WBGT taken at the Garrison Medical Centre, Episkopi and that taken one mile into the field exercise training area. On average the training area WBGT was 1.43°C (range 3.7–0) greater than at the medical centre.

**Type and duration of activity**

The distribution of the type of activity causing heat incidents is shown in Figure 6. The activities are broken down into the various forms of physical exercise that a service person may be required to undertake. The ICFT (Infantry Combat Fitness Test) is a specific speed march over eight miles in 1 hour 50 minutes. Other speed marches are included in the 'March' category. The other activities are divided into Military runs conducted during military training, 'org runs' (organized runs) conducted as an organized sporting activity and 'vol runs' (voluntary runs). Military exercises include all field training activities that do not specifically involve physical training. Other activities include assault course training, sun bathing, canoeing, etc. It can be seen that the primary activity which causes casualties in visiting units is military exercises whilst ICFT's is the primary cause for Cyprus-based units.

**Types of unit involved in heat incidents**

There were casualties from 14 different visiting units from a total of 84 visiting units. Units may be divided into Regular Army and Territorial Army (TA). The Regular Army Units may be subdivided into Arm or Service. The records for visiting units were compared with the recorded casualties. Unfortunately the unit records available ran from May 1990–December 1994. This reduces the total population for the incidence calculations. There were also casualties from four units that could not be identified from the visiting unit records. Thus there were 10 units and 60 casualties available for this analysis.

The type of unit and number of personnel involved for all Episkopi visiting exercises from May 1990–December 1994 are shown in Figure 7. The overall incidence was 0.05% out of a total of 10,702 personnel. The majority of units did not have any heat incidents. However it is clear that TA units visiting in the summer had a much higher rate of casualties per soldier (1.73%) and also a higher ratio per number of visiting units (0.4) than any other unit. This is probably due to a combination of factors including: low level of physical fitness within the unit, minimal acclimatization and lack of experience of junior commanders. In spite of adherence to sensible limits to avoid heat casualties (no activity between 11:00–15:00, and further limitations according to WBGT) one TA unit had 14 casualties, the majority of which occurred at night. There were six multiple casualty incidents with one incident causing 19 casualties. Three TA units had more than one incident with two units having six and nine incidents respectively.

**Severity of heat illness and predisposing factors**

The distribution of severity of heat illness is shown in Figures 8 and 9. Figure 8 compares the distribution of severity between Cyprus-based units and visiting units. In this chart each bar represents the per cent of the total of casualties in each group (total, Cyprus

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**Figure 6. Distribution of cases by activity (Episkopi 1989–94)**

**Figure 7. Numbers of visiting personnel and casualty rates**
and visiting units) so that the proportions are standardized and can be compared directly. Figure 9 shows a comparison between the severity of heat casualties in each year of this study.

It can be very difficult to differentiate between mild heat exhaustion (a casualty attributable to the heat) and exhaustion in the heat (a casualty not attributable to the heat) so there may be over-reporting from medical units that are aware of the problems of heat illness. The visiting units had a higher proportion of mild casualties and fewer severe casualties compared to the Cyprus-based units. The number of mild cases showed substantial variation between the years.

Moderate and severe casualties create a serious loss of manpower as casualties will be placed on restricted duties for several weeks after recovery or may even have their medical grading reduced. These casualties are the ones that preventive measures are aimed at and thus may represent a failure of preventive measures. The number of severe casualties remains fairly constant per year.

The predisposing factors that were identified as contributing to each individual casualty are shown in Figure 10. Inadequate acclimatization was the leading cause. This cause was cited for all visiting unit heat casualties because it was not possible for them to be fully acclimatized during their short stay. In specific incidents it was also possible to identify individual factors such as personnel selection, choice of activity, provision of rest or water, adequacy of first aid training, provision of emergency medical support, etc. that acted synergistically to create a crisis.

DISCUSSION

Overview

This study is one of very few epidemiological surveys of heat casualties in the military forces. The reporting system ensures that all personnel who collapse in heat and who require medical attention in Episkopi, Cyprus are reported. For mild cases, if the casualty’s rectal temperature is not raised it can be difficult to establish if the collapse was a consequence of exposure to heat. If there is no other medical explanation for the collapse (e.g., epilepsy, hypoglycemia) it is likely that physical and mental exhaustion are also contributory factors. All of these, including heat exposure, are under the control of the unit commander and thus the casualty is potentially preventable. If the casualty has a raised core temperature then the association with environmental temperature is clear. Moderate and severe cases will be associated with heat. No distinction was made between heat exhaustion and heat stroke because this was not of any epidemiological value as both conditions may require admission to hospital and intensive treatment. The study was based in primary care and so avoided the selection bias of hospital-based analyses. The study enabled an estimate of the incidence of heat illness to be made for the visiting unit casualties. It was also possible to correlate casualty numbers with measures of environmental temperature. This combination of data is superior to any other study reported for the British Armed Forces. The total number of
cases is one of the largest case series reported in the recent literature.

Unfortunately the study design required a partial retrospective analysis of the data and it was not possible to establish the reliability of the reporting for the collection period 1990–1992. There has to be doubt about the validity of the data collection for 1992 when only two casualties were reported. The case definition could be criticized for lack of precision, however the method chosen ensures that the loss of manpower attributable to the heat is measured.

A major source of bias in the comparison between Cyprus-based units and visiting units was the variation in the activities each group was likely to perform. There was considerable variation in the population of Cyprus-based soldiers because there were many soldiers deployed away from Cyprus during the study period. During the periods when resident troop numbers were reduced the remaining troops were less likely to conduct activities likely to cause heat casualties because of other commitments, e.g. additional guard duties. Thus the actual numbers of Cyprus-based soldiers exposed to the same risk of heat casualties as visiting unit soldiers varied throughout the study period.

At first glance this study seems to suggest that there is a major problem with heat illness in Cyprus amongst British soldiers. However this needs to be put in perspective. There were approximately 10,700 visiting soldiers to Cyprus during the study period. The training undertaken by these soldiers has to be realistic and relevant to the potential requirement to wage war. Yet there were only 64 casualties (0.6%). The majority of incidents involved single casualties which suggests that these individuals were more heat-susceptible compared to the remainder of the group exposed. The guidelines are based on the reduction in the rate of heat illness in a population and consequently this has substantial limitations when applied to the reduction of the risk of heat illness for individuals. It is reassuring to note that there were only 10 severe cases during the 5-year study period.

Distribution of heat casualties

It is not possible to compare true incidences of heat illness between years because an accurate figure for the population at risk cannot be determined. The reports for 1989–1992 were collected for analysis retrospectively. The data for 1993 and 1994 was collected prospectively. Thus the increase in cases in 1993 and 1994 may be a result of a collection bias as opposed to a true increase in cases. The monthly distribution conforms to that expected on theoretical grounds with the majority of cases occurring during the hotter months of the year.

Environmental temperature

The wide daily variation in WBGT precludes the use of historical records for detailed prediction of environmental temperature. However the records show the WBGT at midday to be in excess of 26°C from June to October each year. Thus unit commanders should use this to guide their choice of activity and timing when writing their training programmes.

The average WBGT for incidents for visiting units was 26.4°C which is very close to the 26°C threshold for discretion for unacclimatized personnel. The average WBGT for Cyprus-based units was 28.4°C which is close to the discretion limit of 28°C for acclimatized personnel. Thus the thresholds could have prevented about 50% of cases if they had been properly applied. However the aim of the guidelines should be to prevent a higher proportion of cases and thus the thresholds should be lowered to prevent more cases. The minimum temperature recorded for an incident was 19°C, but to lower the threshold to this level would effectively preclude the majority of military training.

The use of the recorded WBGT as a guide to the efficacy of the guidelines is limited by the variation between the value recorded at the Garrison Medical Centre and that to which the casualty has actually been exposed. The WBGT monitor in use is a Metrosonics hs360 Heat Stress Monitor. This is a delicate instrument which is unable to stand up to the rigours of use during field exercise training.

Type and duration of activity

The results show that there are essentially two types of activity which caused heat casualties in this study population. The first is a bout of exercise of which forced marching is the primary example. This is usually of moderate duration (less than 2 hours) and moderate intensity. Forced marching is usually performed in military uniform with long trousers and carrying a heavy load. This generates a significant metabolic heat load and body cooling is inefficient because efficient evaporation is prevented from a substantial part of the body surface area. Furthermore it is often impractical to have enough water stops to completely replace the fluid debt incurred by sweating. Casualties attributed to physical training of this type can be prevented by specific guidelines based on the combination of work rate, clothing and environmental temperature.

Military training exercises were the major source of heat casualties. These are often of several days duration. During this time soldiers inevitably become deprived of sleep and frequently they become dehydrated in spite of adequate water provision. A major responsibility of junior commanders in these conditions is to ensure that their soldiers drink an adequate quantity of water. The final provoking factor is often a speed march or fighting assault which provides the metabolic heat load to upset thermal equilibrium. Thus the common cause for heat illness is always physical activity but field training exercises reduce individual physiological tolerance to raised environmental and metabolic temperatures. It is much more difficult to devise explicit guidelines to prevent heat casualties in
these circumstances because of the large number of relevant variables.

Types of unit involved in heat incidents

It is clear that the activities which cause casualties for Cyprus-based units are different from those causing casualties for visiting units. This may be distorted by a variation in the numbers of troops exposed. All visiting units conduct field exercises during their stay in Cyprus. Cyprus-based units spend a much smaller proportion of their time on exercises. However in terms of prevention, Cyprus-based units can reduce the number of heat casualties by a more selective choice of physical training whereas visiting units need to focus on military exercises to reduce their heat casualties. Within the group 'visiting units' it is the TA units that have the highest incidence of heat casualties. The TA have a greater range of physical fitness amongst their soldiers. Additionally there is a wider range of military experience amongst junior commanders. Thus it is easy to identify several probable reasons why TA units have a higher incidence of heat casualties. It would be possible to advise TA units not to visit Cyprus during the summer months. This would prevent these exercises happening completely because the TA can only conduct exercises of this length during the summer. Such trips are also an important motivating factor for attendance. Thus it has been decided that these exercises should continue but the unit commanders should now be made fully aware of the potential risks involved.

Severity of heat illness and predisposing factors

The majority of casualties in the study were mild. There were only 10 severe cases. There were no obvious predisposing factors that separated this group from the moderate or mild cases. The primary predisposing factor for all cases in this study was lack of acclimatization. This was presumed to be a contributory factor in every heat casualty from a visiting unit. However, apart from lack of acclimatization, it was possible to identify predisposing factors for heat illness retrospectively in very few individual cases. Thus, although many factors have been identified as contributing to heat illness, it is very difficult to use this information prospectively to reduce heat casualties. Furthermore we could not identify why certain individuals from a group exposed to the same conditions should become a heat casualty whilst the remainder do not. Certainly it would be very valuable to be able to measure the core temperature of all soldiers exposed to heat at the time an individual becomes a heat casualty. This would give a measure of the incidence of raised core temperature as opposed to the incidence of heat casualties and may help identify why some individuals are more susceptible than others.

Three cases had a previous episode of heat illness prior to the incident reported. This might be seen as a failure to identify a risk factor and thus a failure of prevention. One of these cases had his medical fitness category reduced. But if all cases of heat illness are to be medically downgraded this in itself would represent a large drain in manpower without good clinical justification for this practice.

CONCLUSIONS

This study fulfilled its objectives. The heat casualty reports were analyzed in detail for the study period. The factors that contributed to the development of heat casualties were identified as the physical activity performed, the type of unit to which the soldier belonged and the environmental temperature. It was not possible to identify any particular risk factors applicable to individuals except lack of acclimatization which applied to all soldiers of visiting units. It seems that the existing instructions might prevent many heat casualties as the incidence of heat casualties is substantially less than the rate of heat intolerance in the population. There were 10 severe cases. There were no particular factors that could be detected retrospectively that could have been used to identify the individuals who were at greater risk than their compatriots.

The estimate of risk of heat illness from an activity of defined work rate at a specified environmental temperature remains imprecise. This study shows that the current guidelines used by the British armed forces in Cyprus do not prevent all heat casualties, though the extent of the reduction of heat casualties by the use of the guidelines is not possible to determine. Military personnel have been physically trained and therefore some thermal protection can be expected from this. Yet this benefit would be counteracted by the effects of wearing military clothing and equipment.

The measure of environmental heat load is in reality an assessment of the 'cooling power' of the environment for the naked man. Conversion of the measure of environmental heat load to a heat stress index requires an additional correction for metabolic heat. Metabolic heat load is a function of exercise intensity which could be determined from tables of the work intensity for standard military tasks. A further correction to make allowance for clothing could be determined by experimentation. An index of environmental heat stress should be identified that reflects a linear expression of thermal load as an indirect measure of environmental cooling power. The threshold limit for environmental heat at a given work rate could then be selected which represents the limit of thermo regulation. The results could be presented in a format similar to Figure 11.

An index of environmental heat suitable for military use has to be simple to measure. The measuring instrument must be robust, as any prediction of heat load is most accurate when the measurements are
performed as near as possible to the site of activity. The index most commonly chosen for military use is the WBGT Index. Although this is easy to calculate, the standard mercury-in-glass thermometers are fragile. There are some electronic instruments which provide a direct readout of the WBGT but these are also vulnerable to damage.

An alternative index is the Wet-Globe Temperature. This is measured using the Botsball which is a more simple and robust device than the WBGT. There is a correlation between the WBGT and the WGT but there may be a wide variation between the two measurements. It is not clear from the literature whether this difference is relevant. There is a paucity of physiological evidence for the superiority of any index of heat stress over another. Thus the WGT may be a more suitable estimation of environmental heat load than the WBGT for the British Army.

The use of guidelines can help reduce the risk of heat illness to populations. However the risk of heat illness to an individual is much more difficult to predict. Firstly it is not possible to detect true heat intolerance without exposure to work in heat. This is a suitable proposition if workers are likely to be exposed to predictable working conditions. However this is impractical for military personnel, not least because of the large numbers involved. Thus heat casualties need to be anticipated whenever soldiers are undertaking intense physical exercise, and casualties are more likely as the environmental temperature increases.

REFERENCES