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Risk factors for heat illness among British soldiers in the hot Collective Training Environment

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ABSTRACT

Background Heat illness is a preventable disorder in military populations. Measures that protect vulnerable individuals and contribute to effective Immediate Treatment may reduce the impact of heat illness, but depend upon adequate understanding and awareness among Commanders and their troops.

Objective To assess risk factors for heat illness in British soldiers deployed to the hot Collective Training Environment (CTE) and to explore awareness of Immediate Treatment responses.

Methods An anonymous questionnaire was distributed to British soldiers deployed in the hot CTEs of Kenya and Canada. Responses were analysed to determine the prevalence of individual (Intrinsic) and Command-practice (Extrinsic) risk factors for heat illness and the self-reported awareness of key Immediate Treatment priorities (recognition, first aid and casualty evacuation).

Results The prevalence of Intrinsic risk factors was relatively low in comparison with Extrinsic risk factors. The majority of respondents were aware of key Immediate Treatment responses. The most frequently reported factors in each domain were increased risk by body composition scoring, inadequate time for heat acclimatisation and insufficient briefing about casualty evacuation.

Conclusions Novel data on the distribution and scale of risk factors for heat illness are presented. A collective approach to risk reduction by the accumulation of 'marginal gains' is proposed for the UK military. This should focus on limiting Intrinsic risk factors before deployment, reducing Extrinsic factors during training and promoting timely Immediate Treatment responses within the hot CTE.

INTRODUCTION

In the UK military, heat illness is an important cause of morbidity that may arise during training^{1–3} and on deployed operations.^{3–6} It occurs when excessive body heat develops under conditions of increased heat stress, to which physical exertion and impaired thermoregulatory capacity may contribute.⁷ The effects of heat illness range from mild symptoms, such as muscular weakness and headache, to severe manifestations, including collapse, coma and death.^{5 8 9} The clinical sequelae experienced by individual soldiers can impact upon operational effectiveness in the wider Service, both before the episode such as interruption or termination of training or mission, immediate treatment and casualty evacuation requirements, acute loss of manpower and subsequently, such as contribution to chronic undermanning, external imposition of restraints to training, critical media coverage.

Key messages

- Among military personnel, susceptibility to severe heat illness is understood in relation to individual (Intrinsic) and Command-practice (Extrinsic) risk factors, as well as to the effectiveness of Immediate Treatment.
- In responses to a questionnaire completed by UK troops deployed to the hot Collective Training Environment (CTE), the prevalence of Intrinsic risk factors was low in comparison with Extrinsic risk factors.
- Intrinsic risk factors would be further reduced by optimising body composition and physical fitness predeployment, whereas improved logistics and appropriate use of Medical support could limit Extrinsic risks during training.
- The majority of respondents were aware of key Immediate Treatment responses.
- Prevention of heat illness can be seen as a 'marginal gains' process, requiring multiple small improvements before and during deployment to reduce the overall impact in the hot CTE.

Effective immediate treatment may prove life-saving in cases of severe heat illness,¹⁰ though the disorder remains more preventable than treatable.¹¹ This view is endorsed by the UK Ministry of Defence (MoD) in Joint Service Publication 539 (JSP 539),⁸ which provides practical guidance on how to reduce the risk of heat illness to as low as reasonably practical. At the tactical level, commanders are expected to identify enhanced susceptibility to heat illness, which can be considered as the individual (intrinsic) risk allied to the command-practice (extrinsic) risk (Table 1). Many of these risk factors are potentially modifiable, so prospective awareness of their scale and distribution may be key to reducing heat-related morbidity. For example, overweight individuals are at disproportionate risk of heat illness and may be identified by body composition measurement (BCM), which is routinely reported in the UK Armed Forces. Engaging at-risk personnel in weight management and healthy weight maintenance strategies could reduce the prevalence of this intrinsic risk factor for heat illness within the Force.¹²

This is important, because the UK military trains in physically austere environments, with the aim of

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Table 1 Risk factors for heat illness during military activities^{8 10}

Intrinsic risk factors	Extrinsic risk factors
Low level of physical fitness	Sleep deprivation
Obesity/excess body fat/high BMI*	Dehydration (insufficient water intake or excessive loss)
Medications (eg, antihistamines, β -blockers)	Nutritional deficit
Intercurrent illness (eg, gastroenteritis, cellulitis)	Inadequate heat acclimatisation
Chronic disease states (eg, cardiovascular disease, sickle cell trait)	Type of activity (eg, running or loaded route march)
Older age (>40 years old)	Type of clothing eg, body armour, impermeable and/or encapsulating uniform

*Categorised by body composition measurement (BCM) in UK military personnel, according to associated general health risk. BMI, body mass index.

subjecting troops and equipment to conditions relevant to operational deployment. In the hot Collective Training Environment (CTE), visiting troops take part in exercises up to Battlegroup (BG) level, with the support of locally based Permanent Training Staff (PTS). These duties present a risk of heat illness to both types of personnel and are therefore subject to the control measures prescribed in JSP 539. In support of a wider evaluation of compliance with JSP 539 in the hot CTE, we undertook a questionnaire-based project to investigate the prevalence of factors associated with heat illness. Our primary aim was to assess the burden of Intrinsic and Extrinsic risk factors for heat illness among British soldiers deployed to the hot CTE. Our secondary aim was to explore awareness of Immediate Treatment priorities for suspected heat illness.

METHODS

In June and July 2014, an Occupational Health team from the Headquarters of the Army Recruiting and Training Division conducted assurance visits to the British Army Training Unit Kenya (BATUK) and the British Army Training Unit Suffield (BATUS) in Canada. Their objective was to evaluate the delivery of Collective Training in accordance with JSP 539. Both visits were scheduled to coincide with hot-weather training and were supported by the Army Medical Directorate Environmental Monitoring Team. In advance of the assurance visits, authority

to conduct a questionnaire-based survey was granted by Joint Medical Command, (JMC reference RCDM/Res/Audit/1036/14/0411), who confirmed that formal ethical approval was not required by the MoD Research Ethics Committee.

The questionnaire was constructed to assess for the presence of Intrinsic and Extrinsic risk factors for heat illness, in addition to self-reported awareness of Immediate Treatment actions (see online supplementary material). Numerical, categorical, multiple choice and polar ('yes'/'no') questions were used. For certain questions predetermined criteria were used to identify responses indicating enhanced risk of heat illness (Table 2). Baseline characteristics of the respondents were also gathered to inform the interpretation of results. In each CTE, PTS were nominated to distribute 325 copies of the questionnaire among exercising BG personnel and fellow PTS. Completion of the questionnaire was voluntary and 7 days were allowed for its distribution and return.

RESULTS

Responses were analysed by individual CTE and also after pooling results. Lack of response to a question was recorded as 'No Response' (NR). Out of 650 questionnaires distributed across both CTEs, 250 (38.5%) were returned adequate for analysis with this rate differing between BATUK (178 returns, 54.8%) and BATUS (72 returns, 22.2%) (Table 3).

The combined data of BATUK and BATUS of reported frequency of risk factors for heat illness in the hot CTE are given in Table 4.

Figure 1 shows self-reported awareness of measures that can mitigate the severity of evolving or established heat illness. Responses to three key questions are displayed as the proportion of respondents in each occupational category (Junior Ranks, Senior Ranks, Commissioned Officers) who were aware, or were not aware, of each measure, or who made NR.

DISCUSSION

This is the first evaluation of intrinsic and extrinsic risk factors for heat illness in a UK military population. It is also the first published report to address the practical application of JSP 539 in the hot CTE. The key findings relate to the frequencies of self-reported risk factors for heat illness, which were relatively low for intrinsic factors and higher for extrinsic factors. If these results are representative of the typical training population deployed to the hot CTE, it would appear that the impact of

Table 2 Criteria for enhanced risk of heat illness, by categorical response

Intrinsic risk factors	Related question	Response indicating no enhanced risk	Response indicating enhanced risk
Low level of fitness	How do you judge your fitness at the moment?	Moderately Fit or Trained or Well Trained	Unfit or Inactive
Low frequency of physical exercise	How many times a week do you undertake physical exercise lasting at least 45 min?	≥ 3 times/week	<3 times/week
High BMI, high % body fat mass	What is your BCM category, if known?	No increased health risk	Increased Risk or High Risk or Very High Risk or Extreme Risk
Dehydration, nutritional deficit, sleep deprivation	While training, have you felt dehydrated/hungry/sleep deprived?	Not At All or Some of the Times	Most of the Time or Always
Intercurrent Illness	Have you continued training while feeling unwell (eg, cold/diarrhoea) during this exercise?	No	Yes

BCM, body composition measurement; BMI, body mass index.

Table 3 Characteristics of respondents engaged in collective training in Kenya (BATUK) and Canada (BATUS)

	BATUK (n=178)	BATUS (n=72)	Overall (n=250)
Rank			
Junior ranks	143 (80.3%)	56 (77.8%)	199 (79.6%)
Senior ranks	21 (11.8%)	6 (8.3%)	27 (10.8%)
Commissioned officers	14 (7.9%)	10 (13.9%)	24 (9.6%)
Role			
BG: Forward subunits (Rifle Coys, Armoured Squadrons, attached Arms)	95 (53.4%)	72 (100.0%)	167 (66.8%)
BG: Rear echelon (HQ Coy elements not deployed to the main training area)	54 (30.3%)	0 (0.0%)	54 (21.6%)
BG: Medical assets	11 (6.2%)	0 (0.0%)	11 (4.4%)
PTS	17 (9.6%)	0 (0.0%)	17 (6.8%)
NR	1 (0.6%)	0 (0.0%)	1 (0.4%)
Median (range) days since arrival incountry*	21 (12–42) (n=143)	31 (19–120) (n=69)	22 (12–120) (n=212)
Medical Employment Standard			
No medical sanction	151 (84.8%)	65 (90.3%)	216 (86.4%)
Medically downgraded	20 (11.2%)	5 (6.9%)	25 (10.0%)
NR	7 (3.9%)	2 (2.8%)	9 (3.6%)
Lifestyle factors			
Use of dietary/exercise supplements	12 (6.7%)	9 (12.5%)	20 (8.0%)
Active tobacco smoking	66 (37.1%)	39 (54.2%)	105 (42.0%)

*PTS responses not included.

BATUK, British Army Training Unit Kenya; BATUS, British Army Training Unit Suffield; BG, visiting Battlegroup personnel; HQ, Headquarters; NR, no response; PTS, Permanent Training Staff.

heat stress can be managed to a low level by protecting vulnerable individuals, optimising preventive Command practices and making timely and appropriate responses to suspected heat illness. Before this hypothesis is explored further, it is necessary to address the question of whether our findings can be considered sufficiently representative to make wider generalisations.

Respondent characteristics and generalisability to other military cohorts

Of all heat illness notified within the British Army between 2009 and 2013, 65% was reported by training units and

sub-Saharan Africa and North America accounted for nearly a quarter of all overseas notifications.³ There are grounds, therefore, to expect that mitigating the risk heat illness in BATUK and BATUS will reduce the impact of heat-related morbidity in the wider Service. The findings of the present project must be interpreted with caution, however, because of the relatively small number of respondents within each hot CTE and the likelihood of enrolment bias. The results presented are based upon voluntary responses to a questionnaire that PTS distributed and collected. This was the only way that sufficient numbers of potential respondents could be accessed in large and remote

Table 4 Distribution of risk factors for heat illness reported by 250 British soldiers in the hot CTE, according to Intrinsic and Extrinsic risk factors

	Number of personnel with risk factor (%)	Number of personnel without risk factor (%)	Number of personnel making no response (%)
Intrinsic risk factor			
Low level of physical fitness	18 (7.2)	232 (92.8)	0 (0.0)
Low frequency of physical exercise	28 (11.2)	222 (88.8)	0 (0.0)
1.5 mile run time >12 min*	9 (3.6)	240 (96.0)	1 (0.4)
Elevated health risk from BCM	34 (13.6)	172 (68.8)	44 (17.6)
Previous heat illness	16 (6.4)	230 (92.0)	4 (1.6)
Possible intercurrent illness	16 (6.4)	233 (93.2)	1 (0.4)
Regular use of risk-associated medications (eg, NSAIDs, antihistamines, β -blockers)	12 (4.8)	231 (92.4)	7 (2.8)
Extrinsic risk factor			
Upon arrival to the hot CTE			
Acclimatisation programme <7 days	208 (83.2)	34 (13.6)	8 (3.2)
No acclimatisation programme	106 (42.4)	136 (54.4)	8 (3.2)
During training in the hot CTE			
Feelings of dehydration	45 (18.0)	205 (82.0)	0 (0.0)
Hunger	53 (21.2)	197 (78.8)	0 (0.0)
Sleep deprivation	83 (33.2)	166 (66.4)	1 (0.4)
Trained while feeling unwell	98 (39.2)	148 (59.2)	4 (1.6)

*Within preceding 3 months.

BCM, body composition measurement; CTE, Collective Training Environment.

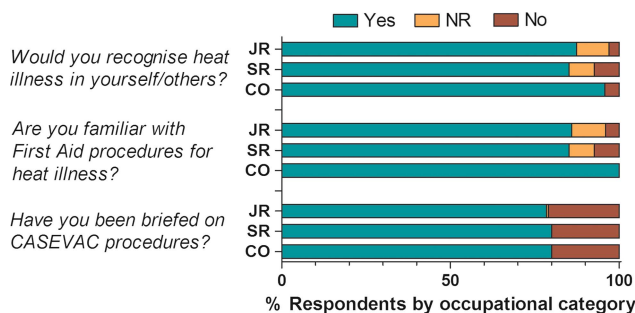


Figure 1 Awareness of key measures to mitigate heat illness reported by British soldiers in the hot Collective Training Environment (CTE). Responses are displayed by occupational category (JR, Junior Ranks; SR, Senior Ranks; CO, Commissioned Officers) as either aware (Yes), unaware (No) or No Response (NR).

training areas, but may have contributed to the relatively low return rate (38.5%) and biased the sample of each BG. For the questionnaires that were returned, the majority of respondents were found to be Junior Ranks (79.6%) and nearly all respondents were deployed as part of a Combat Arms BG (92.8%). Among these returns, the ratio of respondents deployed in the main training area to those held in the rear echelon (ie, forward:rear) was a little over 3:1. At least 10% of respondents were medically downgraded, up to 4% were unable to complete a 1.5 mile run in under 12 min and at least 13% were adjudged to be at increased risk of adverse health outcomes on the basis of BCM scoring.

The bias towards rear echelon personnel arose in returns from BATUK and provides a basis for including returns from BATUS, which were made exclusively by 'Forward' BG troops, albeit at a very poor rate of response. Overall, the respondent characteristics appear quite similar to those of the BG populations sampled and to available British Army figures. Within the same training year, 94–98% of personnel in the units contributing to each BG had achieved a 1.5-mile run time categorised as 'Good', which is <12 min in men aged under 44 years old. The proportion of individuals placed at 'increased risk' or greater by BCM scoring varied from 14% to 24% among contributing units and, in the wider Army, the medically downgraded rate was as high as ~21%.¹³ The proportion of respondents making NR within each area of these areas of enquiry was not dissimilar to the percentage of missing records at each unit (ie, the proportion of personnel without a documented 1.5 mile run time or BCM score). It would appear, then, that any bias towards rear echelon personnel did not grossly compromise the sample in the direction of poorer run times or greater BCM risk (versus the wider BG populations) or greater pre-existing medical morbidity compared with the British Army as a whole.

Recent data concerning physical activity levels have been published for Army personnel based at UK training establishments, including recruits, in whom just 1.0% of respondents described their physical activity levels as 'low'.¹⁴ Respondents in BATUK and BATUS were self-reportedly 'inactive' or 'unfit' in 7.2% of cases and 11.2% engaged in physical exercise less than three times a week, but this apparent variation may simply reflect the difference between physical activity levels in personnel based at deployable field units versus those undergoing training and selection courses in the UK. If these uncertainties are borne in mind, then respondents in BATUK and BATUS may be considered sufficiently representative of their parent units to draw preliminary conclusions. The following considerations may, therefore, be of value to similar BGs deploying into the hot CTE.

Intrinsic risk of heat illness

The overall prevalence of intrinsic risk factors for heat illness appeared low, but a number of individuals were judged to be at enhanced risk in relation to personal fitness standards and BCM category. In the absence of data specific to the trained strength of the UK military (men and women), relationships between physical fitness standards and risk of military heat illness have been derived from studies of male recruits to US Armed Forces. During US Army basic training, low levels of physical fitness¹⁵ and excessive body fat¹⁶ have been shown to be independent predictors of heat illness and US Marine Corps recruits with body mass index (BMI) ≥ 22 kg/m² who took 12 min or more to complete a 1.5 mile run were at eightfold greater risk of heat illness versus those with faster run times and lower BMI.¹⁷ While medical downgrading per se may not increase the risk of heat illness, individuals who are unable to maintain frequent exercise regimens and fitness levels may be placed at increased risk during military training.¹⁸ Of respondents to the questionnaire reported here, no more than 4% had failed to achieve a 1.5 mile run time of below 12 min, despite the 10% medical-downgrading rate, whereas 13.6% reported an elevated BCM score. By inference, the size of the threat of heat illness from excessive body fat and higher BMI may have been greater than that associated with poor aerobic fitness and downgraded Medical Employment Standard. This is relevant, because fitness and body composition have the potential to be improved in a graded and safe manner before arrival to the hot CTE, but may need to be approached in different ways (eg, types of training, dietary strategies).

Less prevalent risk factors included a previous history of heat illness (6.4%), possible intercurrent illness (6.4%) and use of medications that may predispose to heat illness (4.8%). These could be reduced further, by appropriate predeployment risk assessment of personnel previously affected by heat illness and prompt medical assessment of suspected illness—including heat illness—within the hot CTE.

Extrinsic risk of heat illness

This project was conducted as part of a wider evaluation of compliance with JSP 539 in the hot CTE. This reported a mature and well developed approach to reducing extrinsic risk factors, but also identified a critical shortfall in the time allowed for heat acclimatisation. Seven days is specified in JSP 539,⁸ yet periods of shorter length were reported by 83.2% of respondents, of whom more than half reported no recognisable acclimatisation programme. Other investigations confirmed that inadequate time had been allocated for troops to acclimatise, with requirements for handover/takeover of equipment and other logistic constraints cited as contributory factors. In unacclimatised personnel undertaking strenuous physical activity, heat illness peaks during the first few days in a hot environment.¹⁹ Taking heat illness casualties early in the course of an exercise will maximally impact upon BG training objectives, due to the medical imperative to remove them from the hot CTE.

In mitigation of these alarming statistics, it should be noted that 54 respondents were based with the rear echelon in Kenya at the time of completing the survey, where the baseline threat of heat illness from the environment and physical activity is substantially lower than in the training area itself. Excluding these troops from the requirement for acclimatisation would effectively halve the proportion of respondents who reported no recognisable heat acclimatisation programme, to approximately 21.0% of all respondents. In common with some PTS, however,

rear echelon troops may be expected to sporadically deploy forwards to the hot CTE itself and special consideration must be given to how the risk of heat illness can be reduced on these occasions. For personnel more permanently based in the hot CTE, future BATUK/BATUS training schedules should include adequate time for heat acclimatisation and BG staff must find imaginative ways of incorporating acclimatisation serials into other routine activity, before formal training begins.

Other areas of extrinsic risk that are directly influenced by Command practices include the provision of hydration, nutrition, sleep and rest. Difficulties in meeting these requirements are recognised features of military operations^{20 21} and appear to have affected 20–30% of respondents in BATUK and BATUS. For UK military personnel, JSP 539 places responsibility upon Commanders to ensure that troops drink sufficient water before, during and after activities associated with a risk of heat illness.⁸ Implicit to this instruction is the task of delivering adequate amounts of potable water, at the correct time and to accessible locations within the hot CTE, and the same requirement holds true for food rations. Some Commanders may ascribe to a practice of putative ‘preconditioning’ for military operations, through depriving personnel of sleep, providing a diet inadequate to maintain energy balance and enforcing severe water discipline during training. Any perceived benefits of this approach must be weighed against the established evidence for reduced training performance²² and increased heat illness risk under such conditions.²³ It is essential that planners in the BG and PTS pay heed to these considerations in the construction of individual training serials and in the phasing of the broader exercise.

The practice of ‘soldiering on’ through minor illness is also relevant to Command practices.⁸ Training while feeling unwell was reported by 39.2% of respondents, including a significant proportion of Senior Ranks and Commissioned Officers (31.4%). These findings emphasise the importance of providing close medical support to troops exercising in the hot CTE, in order to facilitate safe training. At a single point in time, medical personnel may be required to assess the healthcare needs and training suitability of only a small number of unwell troops, but a large proportion of the BG may require this service over the course of an entire exercise if heat illness is to be avoided.

Immediate treatment for suspected heat illness

Methods for the prevention of heat illness are more effective than those available for its treatment.¹¹ When prevention fails, measures to reduce the severity of illness include early recognition, appropriate first aid management and prompt evacuation to medical care.¹⁰ Compared with training in the Firm Base, deployment to the hot CTE may be associated with additional constraints to monitoring and responding to critical heat stress, secondary to realistic simulation of operational deployment. This requires Service personnel to possess a basic but firm grasp of how heat stress and heat illness are mitigated. Our results show that most respondents felt confident in this regard, though actual knowledge relating to immediate treatment was not assessed and some of this confidence may have been misplaced. The largest shortfall in awareness concerned casualty evacuation, with almost a quarter of the surveyed population reportedly receiving no formal briefing of procedures to initiate this. The number of personnel from the Ranks who made NR to questions about the recognition and treatment of heat illness was not insubstantial. When these responses are combined with those declaring frank lack of knowledge, a significant area of modifiable risk

emerges. This could be addressed by ensuring appropriate education and direction on the response to heat illness, in advance of deployment and on arrival to the hot CTE.

Additional considerations

In the populations surveyed, respondents from the Combat Arms are expected to have predominated over those from other Arms and Services and markedly different risk profiles may prevail in formations weighted towards other capabilities such as engineering and medical. Given that the proportion of respondents subject to medical downgrading in BATUS and BATUK (10.4%) was only half that reported for the Army during the same year (21%),¹³ it is possible that the reported risk of heat illness was lower than would be found in a Force more widely representative of the British Army.

The respondent smoking rate of 42.0% was in agreement with the work of Boos *et al*,²⁴ who reported a prevalence of 46.0% in British soldiers deployed to the hot operational environment of southern Afghanistan in 2010 and 42.0% among regular British Army troops at point of deployment to Iraq in 2003.²⁵ A recent study of Army training establishments in the UK found a lower, but still substantial, smoking prevalence of 29%.¹⁴ Direct evidence of a role for tobacco in the development of heat illness is lacking, but smoking-associated risks that could precipitate or contribute to an episode in military personnel include decreased physical fitness^{26 27} and intercurrent illness.^{19 28 29} It is disappointing that the requirement to achieve significant reductions in smoking among British Army personnel^{23 25} is yet to be met in the training environment and a fresh approach to prevention may be required. In contrast, the use of dietary and exercise supplements was much lower than reported for UK military personnel deployed on operations to Afghanistan in 2010 (40.2%)²⁴ and Iraq in 2009 (32.0%)³⁰ and for British Army personnel attending UK-based training establishments in 2010/2011 (38%).¹⁴ If corroborated in a larger study, this finding may reflect the impact of recent efforts within the UK military to reduce illicit, unnecessary and potentially dangerous³¹ supplementation practices.

Future research

To minimise the risk of heat illness in the hot CTE, Commanders and Medical personnel are required to implement the guidance from JSP 539 in a dynamic and comprehensive fashion. Processes of similar complexity are encountered in civilian practice, where there is a growing appreciation of the large benefits that may accrue from aggregating multiple, seemingly miniscule, improvements. Having met with success in the arena of professional sport,³² proponents of ‘marginal gains’ theory are developing this approach to improve clinical outcomes in high-risk healthcare settings.³³ Future research should address whether heat illness can be reduced—or even eliminated—by coordinating attempts to proactively identify and modify the multiple risk factors that may exist in different UK military populations and CTEs.

An emerging area of academic and practical interest is centred on the differential responses to heat stress and exercise observed between male and female subjects.^{34 35} Female soldiers and officers were known to be represented in only small numbers among the BG and PTS populations surveyed and permission to undertake the project was subject to gender anonymity, because of the risk of identifying female respondents by their stated rank and other characteristics. With the emergence of women in front line roles on recent deployments, and female entry into the Combat Arms ensuing from recent MoD policy changes, the

relevance of intrinsic risk factors that have been described in largely male military cohorts should be investigated with particular regard to female Service personnel.

CONCLUSIONS

This evaluation highlights the significant challenge of preventing heat illness in the hot CTE. The threat posed by heat illness is seen to prevail in multiple domains, where risk factors must be recognised before modification or mitigation is possible. The most frequently reported factors within each domain were excess body fat/high BMI (as indicated by BCM category), inadequate time for heat acclimatisation and incomplete briefing of Casualty Evacuation, Non Steroidal Anti-Inflammatory Drug (CASEVAC) procedures.

It is important, therefore, that BGs are mindful of the need for prior preparation of personnel and correct implementation of the guidance provided in JSP 539, in advance of deployment to the hot CTE. Once arrived in BATUK/BATUS, particular attention should be paid to ensuring adequate heat acclimatisation, sensible training practices and timely Immediate Treatment of suspected heat illness cases.

Future research should determine the particular risks harboured by other training populations, including female cohorts, and within different CTEs. The question of whether serious heat illness can be eliminated from UK military practice by engagement in a 'marginal gains' approach to risk reduction also merits attention. This should enfranchise the full spectrum of personnel who influence the incidence of heat illness within the hot CTE, including key BG members and PTS.

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