

**HEAT INJURY MANAGEMENT  
IN THE SAF**



**A Report by the  
External Review Panel on  
Heat Injury Management**

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# **EXECUTIVE SUMMARY**

## **BACKGROUND**

1. In May 2018, MINDEF commissioned an External Review Panel on Heat Injury Management (hereinafter referred to as “The Panel”) to examine the SAF’s heat injury policies and processes. The Panel was headed by A/PROF MARK LEONG KWOK FAI, Senior Consultant, Department of Emergency Medicine, SGH, who was supported by:

- a. A/PROF MARCUS ONG ENG HOCK, Senior Consultant, Department of Emergency Medicine, SGH;
- b. A/PROF KELVIN CHEW TAI LOON, Director and Senior Consultant, Changi Sports Medicine Centre, CGH;
- c. DR TEOH CHIN SIM, Director and Senior Consultant, Sports Medicine Centre, KTPH; and
- d. A/PROF JASON LEE KAI WEI, Programme Director, Human Performance Programme, Defence Medical & Environment Research Institute, DSO National Laboratories.

## **GENERAL IMPRESSIONS**

2. The Panel found that the SAF’s heat injury measures were generally sound and aligned with prevalent industry and foreign military practices. The Army’s Training Safety Regulations (TSR) on hot weather operations were broadly similar to regulations promulgated by advanced armed forces<sup>1</sup>, while the SAF’s medical responses were closely aligned with the SAF-MOH Clinical Practice Guidelines 1/2010: Management of Heat Injuries.

3. The SAF has put in place a broad range of heat injury prevention measures<sup>2</sup>. It has also invested substantial resources to prevent and treat heat injuries. These investments include research studies, improved load-bearing vests and uniforms, specialised cooling equipment and a responsive casualty-evacuation system. The Panel also found that the training

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<sup>1</sup> The SAF’s heat injury prevention measures were compared to those employed by the US Army, Air Force and Marines; UK MOD; the Australian Defence Force and NATO.

<sup>2</sup> The 6 main measures listed in the TSR are: (1) Hydration regime; (2) Work-rest cycles based on Wet Bulb Globe Temperature; (3) Heat acclimatization and progressive training; (4) Rest management; (5) Outlier management; and (6) Temperature taking regime.

regimes provided to SAF medical officers and medics are in line with national requirements.

## **OBSERVATIONS AND RECOMMENDATIONS**

4. The Panel raised several observations and recommendations for the SAF's consideration. The key themes underlying the recommendations were:

- a. Fine-tuning the SAF's heat injury prevention measures.
- b. Ensuring early recognition and evacuation of heat injury cases.
- c. Providing effective cooling to heat injury casualties.

5. Fine-tuning heat injury prevention measures. The Panel suggested several additions to the SAF's range of heat injury prevention measures. The recommendations included improving heat injury awareness, fine-tuning work-rest cycles, extending the use of during-activity cooling and setting upper hydration limits. The Panel also felt there was a need for the SAF to address impediments to self-reporting that may discourage soldiers from speaking up when they feel unwell.

6. Ensuring early recognition and evacuation. The Panel emphasised that the early recognition of heat injuries was the most important element of their recommendations. Commanders, conducting staff and soldiers all have key roles to play in recognising signs and symptoms of heat injury in their fellow soldiers. They should then take action, as prescribed in the TSR, to ensure that first aid is rendered and casualties are evacuated as soon as possible. Commanders and medics should err on the side of caution because it is difficult to accurately determine the degree of heat injury. When in doubt, all suspected heat stroke cases should be evacuated to a medical facility, where they can receive further assessment and treatment.

7. Providing effective cooling. The Panel emphasised that the treatment of heat casualties should involve three key principles: (1) rapid cooling of body core temperature; (2) stabilising the casualties and evacuating them to hospital as early as possible; and (3) continuing the cooling process while en-route.

- a. The Body Cooling Unit (BCU) is the main cooling modality for treating heat injury casualties in the SAF. The Panel recommended that HQ MC should promulgate standardised heat injury treatment protocols to better guide the MOs, senior medics and paramedics who operate the BCUs. HQ MC should also establish formal

escalation channels so that MOs can seek guidance and advice from senior SAF physicians when handling medical emergencies.

b. While the BCUs have served the SAF well, research suggests that there are newer and more effective rapid cooling methods, such as cold water immersion and cooling suits. The Panel felt that the SAF should evaluate these methods, with a view to augmenting or eventually replacing the BCUs. The SAF should also invest further in portable cooling equipment, which would allow casualties to undergo rapid cooling while being transported to a medical facility.

## **CONCLUSION**

8. The SAF has invested substantial effort and resources towards heat injury prevention and treatment. The resultant heat injury measures are generally sound and aligned with prevalent industry and foreign military practices. There is, however, scope for further enhancements and the Panel has surfaced several recommendations that we hope will help the SAF: (1) fine-tune its heat injury prevention measures; (2) ensure early recognition and evacuation of heat injury casualties; and (3) provide casualties with more effective rapid cooling.

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# **HEAT INJURY MANAGEMENT IN THE SAF - A REPORT BY THE EXTERNAL REVIEW PANEL ON HEAT INJURY MANAGEMENT**

## **INTRODUCTION**

1. In May 2018, MINDEF commissioned an External Review Panel on Heat Injury Management (hereinafter referred to as “The Panel”) to examine the SAF’s heat injury policies and processes. The Panel was headed by A/PROF MARK LEONG KWOK FAI, Senior Consultant, Department of Emergency Medicine, SGH, who was supported by four experts in relevant fields of medicine and research:

- a. A/PROF MARCUS ONG ENG HOCK, Senior Consultant, Department of Emergency Medicine, SGH;
- b. A/PROF KELVIN CHEW TAI LOON, Director and Senior Consultant, Changi Sports Medicine Centre, CGH;
- c. DR TEOH CHIN SIM, Director and Senior Consultant, Sports Medicine Centre, KTPH; and
- d. A/PROF JASON LEE KAI WEI, Programme Director, Human Performance Programme, Defence Medical & Environment Research Institute, DSO National Laboratories.

2. Terms of Reference. The Panel was requested to review and recommend improvements to the SAF’s heat injury management measures.

## **APPROACH**

3. The main review activities were conducted in May to July 2018:

- a. Preliminary Discussions. Preliminary discussions between Panel members and MINDEF’s Safety and Systems Review Directorate were carried out over four sessions in May 18.
- b. Visit to the SAF Medical Corps (28 May 18). The Panel received briefs on: (1) The Army’s heat injury policies and processes; (2) Initiatives to improve soldier performance; and (3) Medical management of heat injuries in the SAF.

- c. Visit to Bedok Camp (1 June 18). The Panel was briefed on the unit training system for a Guards battalion and the ground measures taken by commanders to avoid heat-injuries. The Panel then visited Bedok Camp Medical Centre and were shown how heat injury casualties would be treated.
  - d. Preparing and Presenting the Panel Report. The Panel's report was drafted in June-July 18 and presented to the Minister for Defence at the Army HQ Meeting on 23 July 18.
4. Apart from the briefs mentioned above, the Panel also reviewed the following directives:
  - a. Army Training Safety Regulations, Chapter 3, Section 2: Operating in Hot Environments. This chapter of the Training Safety Regulations (TSR) outlines the measures for the prevention, recognition and early management of heat injuries.
  - b. Preventive Medicine, PM-20: Management of Heat Illnesses in the SAF. This medical directive provides information on the prevention, treatment and evacuation of heat casualties.
  - c. Healthcare, HC-47: Guidelines on Peacetime Casualty Evacuation and Transfer. This medical directive provides guidelines on the evacuation and transfer of SAF casualties.
5. The SAF's practices were compared against four benchmarks:
  - a. Best Practices from Emergency Medicine, Sports Science and Human Performance Research. This was based on inputs from the Panel's subject matter experts as well as research insights and findings related to heat injuries.
  - b. SAF-MOH Clinical Practice Guidelines 1/2010: Management of Heat Injuries. These guidelines were developed in 2010 by a panel of leading practitioners and remain the primary benchmark for the management of heat injuries in Singapore.
  - c. Foreign Military Practices. This was based mainly on documents from the US, UK, Australia and the North Atlantic Treaty Organisation (NATO)<sup>3</sup>.

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<sup>3</sup> References include: (1) USA - HQ Department of the Army and Air Force TB MED 507/AFPAM 48-152 (I), Heat Stress Control and Heat Casualty Management; (2) US Marine Corps Order 6200.1E W/CH 1, Heat Injury Prevention Program; (3) UK - MOD JSP 539 V3.0 May 17, Heat Illness and Cold Injury;



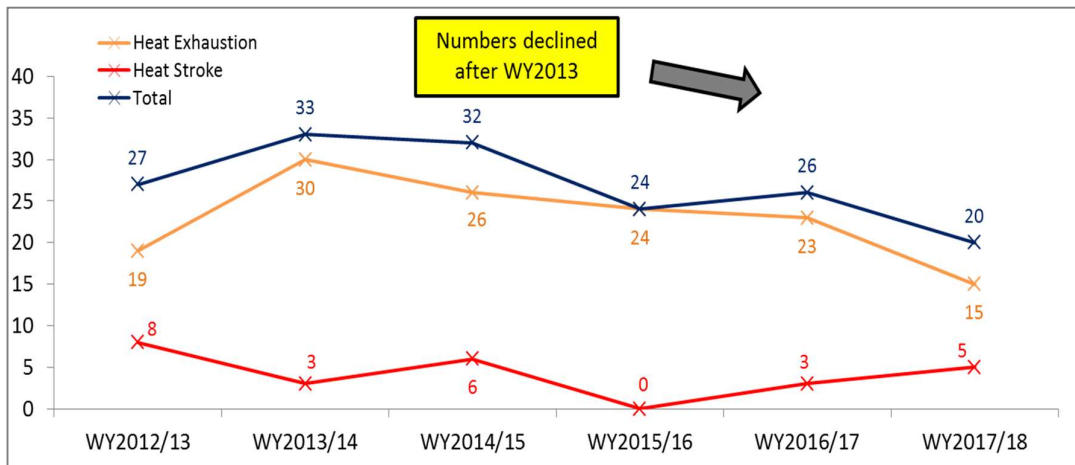
d. Workplace Safety and Health Guidelines: Managing Heat Stress in the Workplace. This booklet was published in September 2010 by the Workplace Safety and Health Council, in collaboration with the Ministry of Manpower (MOM).

## GENERAL IMPRESSIONS

6. The Panel found that the SAF’s heat injury measures were generally sound and aligned with prevalent industry and foreign military practices. The Army’s TSR on hot weather operations were comparable to regulations promulgated by advanced armed forces, while the SAF Medical Corps’ heat injury protocols (PM-20) were closely aligned with the SAF-MOH Clinical Practice Guidelines 1/2010: Management of Heat Injuries.

7. The last major review of the SAF’s heat injury prevention measures was done in 2013. A Heat Injury Prevention Task Force, led by Comd 9 Div/Chief Infantry Officer, was formed to address a rising trend of heat injuries and succeeded in reversing the trend. (See **Chart 1**) The Task Force’s recommendations and other measures that have been implemented since then are key components of today’s heat injury prevention effort.

Chart 1: Heat Injury Trend in the Army.



8. The main measures currently employed by the SAF to minimise the incidence of heat injuries are as follows:

- a. Hydration regime;
- b. Work rest cycles based on Wet Bulb Globe Temperature;

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Prevention and Management, Part 2: Guidance; (4) ADF – Health Directive No. 286, Health Management for the Prevention and Treatment of Heat Casualties within the ADF; and (5) NATO-TR-HFM-187, Management of Heat and Cold Stress Guidance to NATO Medical Personnel.

- c. Heat acclimatization and progressive training;
- d. Rest management;
- e. Outlier management; and
- f. Temperature taking regime.

9. These measures are also widely used, to varying degrees, by foreign forces and local industry. (See **Table 1**)

Table 1: Comparison of SAF Heat Injury Prevention Measures against Foreign Military Forces & Industry<sup>4</sup>

Heat Injury Prevention Measures	SAF	US	UK	NATO	ADF	Industry
Hydration Regime	✓	✓	✓	✓	✓	✓
Work Rest Cycle based on WBGT	✓	✓	✓	✓	✓	✓
Heat Acclimatisation & Periodisation	✓	✓	✓	✓	✓	✓
Rest Management (7 hrs of rest)	✓	✓	×	×	×	×
Outlier Management	✓	✓	×	×	×	×
Temperature Taking Regime	✓	×	×	×	×	×

10. The SAF has invested substantial resources, and worked with partners like DSO National Laboratories and institutes of higher learning to prevent and treat heat injuries. These investments include:

- a. Research studies on hydration, heat acclimatisation and cooling;
- b. Improved load-bearing vests, uniforms and boots;

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<sup>4</sup> This comparison is based on measures listed in the respective documents mentioned in paragraphs 5c and d.

- c. Safety vehicles equipped with cooling means, deployed to support units engaged in high-tempo training;
- d. Specially designed cooling-packs<sup>5</sup> that can be used in the field to treat heat-stressed soldiers; and
- e. Purpose-built Body Cooling Units (BCUs), which have been deployed in 30 SAF Medical Centres. Similar BCUs are used in three restructured hospitals.

11. The SAF has also established a responsive evacuation system to quickly evacuate heat casualties to suitable medical facilities. Besides operating its own fleet of ambulances, safety vehicles and medevac helicopters, the SAF also has dedicated access to six specially configured ambulances contracted under the Emergency Ambulance Service<sup>6</sup>. Evacuation coverage extends to all SAF training areas, including offshore islands like Pulau Tekong and overseas training areas. The evacuation process has been reviewed on numerous occasions, internally and by external committees of inquiry, and found to be sound.

12. The Panel found that the training regimes for SAF Medical Officers (MO) and medics are in line with national requirements.

- a. SAF MOs are qualified medical doctors who are re-enlisted into the SAF upon obtaining their full registration with the Singapore Medical Council. Prior to their return, they are required to complete a 3-month posting in either Emergency Medicine or Anaesthesia to hone their resuscitation skills. During their Medical Officer Cadet Course, MOs undergo training in various aspects of military medicine, including advanced cardiac life support and advanced trauma life support<sup>7</sup>. Post-commissioning, they attend monthly Grand Rounds<sup>8</sup> as part of their Continuing Medical Education (CME). MOs posted to medical centres are required to partake in CME together with their medics. This includes quarterly

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<sup>5</sup> EMCOOLS is a portable cooling system carried on ambulances contracted under the Emergency Ambulance Service. The medical centres of the SAF Overseas Training Centres are also provided with such cooling-packs. In addition, the on-site medical posts for major SAF exercises or events are equipped with EMCOOLS.

<sup>6</sup> SAF EAS is a contracted service where private ambulance operators provide ambulances on standby at 6 SAF medical centres (Mandai Hill, Nee Soon, Kranji, Keat Hong, Pasir Laba and Sungei Gedong). Each ambulance is to be equipped with a portable cooling system (EMCOOLS).

<sup>7</sup> The Advanced Cardiac Life Support Course (ACLSC) and Advanced Trauma Life Support Course (ATLSC) have a 2 and 4 year validity period respectively.

<sup>8</sup> Grand Round (or Grand Ward Round) is a monthly training seminar organized by HQMC for all SAF MOs. The half-day session typically involves a medical subject matter expert, either from hospitals or from the SAF, who will present and share insights on clinical topics that are relevant to the SAF.

sessions of protected training time, which consists mainly of team-based training conducted within the Medical Simulation Training Centre at the SAF Medical Training Institute (SMTI). Finally, MOs are required to undergo annual summative assessments of their respective medical centre's emergency response chain.

b. SAF medics must successfully complete 11 weeks of residential training at SMTI in order to be qualified. The curriculum for their training was co-developed with the Justice Institute of British Columbia, with protocols developed in consultation with the Emergency Medicine Specialist Advisory Board (EMSAB)<sup>9</sup>. Singapore Civil Defence Force paramedic trainees are also trained alongside SAF medics in SMTI as part of their qualification training. Beyond this ab-initio training, SAF medics go through a proper regime of currency training, which includes daily/weekly resuscitation drills, fortnightly medical training sessions and quarterly team-based training. All medics must undergo an annual medic proficiency test, which is a mandatory requirement before they can perform medic cover duties.

## **OBSERVATIONS AND RECOMMENDATIONS**

13. While the SAF's heat injury measures are generally sound, the Panel would like to raise several observations and recommendations for the SAF's consideration. The recommendations may be broadly classified under three main themes:

- a. Fine-tuning the SAF's heat injury prevention measures.
- b. Ensuring early recognition and evacuation of heat injury cases.
- c. Providing effective cooling to heat injury casualties.

### **Fine-Tuning the SAF's Heat Injury Prevention Measures**

#### *Improving Heat Injury Awareness*

14. SAF personnel currently receive introductory training on heat injuries during basic military training and various command courses. Heat injury matters are also covered in the safety advisories that the Army

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<sup>9</sup> EMSAB is a board of external medical experts set up to advise the SAF Medical Corps on issues relating to Emergency Medicine. The medic training protocols were developed in consultation with the then-Chairman of EMSAB in 2013.

Safety Inspectorate (ASI) periodically issues via email to keep the ground informed of issues of concern. ASI has also produced useful educational videos, which are vivid and illustrative, to complement written or verbal descriptions.

15. The Panel feels that heat injury awareness can be improved by enhancing training and currency requirements. ASI's advisories and videos are useful and should be incorporated both into existing courses as well as into a formal currency training system. For currency training, the Army could consider adopting the ADF's practice of requiring servicemen to attend a mandatory annual Army Force Preservation Awareness Training package, which includes a module on heat injuries. The Army should also review its annual TSR test to ensure that heat injury issues are adequately covered.

16. The Panel further recommends that heat injuries should be featured more prominently in the weekly/fortnightly/quarterly currency training that SAF medics undergo. The annual proficiency test for medics should also include heat injury management as a compulsory test scenario.

17. The Panel also recommends expanding the Army's list of risk factors that may predispose an individual to heat injuries. The 16 risk factors<sup>10</sup> listed in Army TSR, Chapter 3, Section 2 are largely similar to what is promulgated by foreign forces. There are, however, four additional risk factors gleaned from foreign military guidelines that the Army should consider adding: inexperienced soldiers, alcohol intake, use of supplements and salt depletion<sup>11</sup>.

### *Fine-Tuning Work-Rest Cycle Guidelines*

18. The Wet Bulb Globe Temperature (WBGT) is an important tool for assessing the heat stress that training troops would be expected to face. In line with other advanced military forces, the SAF has promulgated Work-Rest Cycles (WRC) for various WBGT bands (See **Table 2**).

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<sup>10</sup> The 16 risk factors are: (1) Strenuous Activities, (2) Accumulated Fatigue, (3) Sleep Deprivation, (4) High Ambient Temperature, (5) High Ambient Humidity, (6) Operating Environment, (7) Clothing, (8) Dehydration, (9) Inadequate Nutrition, (10) Previous History of Heat Injury, (11) Concurrent or Recent Illness, (12) Medications, (13) Poor Physical Conditioning, (14) Obesity, (15) Highly Motivated Soldiers, and (16) Introverted Soldiers.

<sup>11</sup> UK - MOD JSP 539 highlights that inexperienced soldiers are more prone to heat injury, advises personnel not to consume alcohol within 48 hours of high-risk activities and warns against the use of supplements that may promote heat retention. ADF Health Directive No. 286 states that salt intake is important to replace the salt lost through sweating.

Table 2: SAF WRC Guidelines for Strenuous Activities.

<b>SAF Work Rest Cycle</b>		
<b>Heat Category</b>	<b>WBGT (deg C)</b>	<b>Work : Rest (mins)</b>
<b>White</b>	<b>29.9 and below</b>	<b>60 : 15</b>
<b>Green</b>	<b>30 to 30.9</b>	<b>45 : 15</b>
<b>Yellow</b>	<b>31 to 31.9</b>	<b>30 : 15</b>
<b>Red</b>	<b>32 to 32.9</b>	<b>30 : 30</b>
<b>Black</b>	<b>33 and above</b>	<b>15 : 30</b>

19. One difference between the SAF's and foreign forces' work-rest guidelines is that the latter imposes additional restrictions on soldiers using body armour and NBC suits. A US soldier wearing body armour would be assumed to be working at WBGT +5°F (+3°C) temperatures. He will have to comply with work-rest guidelines for this higher temperature. A US soldier in an NBC suit would be assumed to be working at WBGT +20°F (+12°C) temperatures. The SAF should similarly factor the effect of such clothing and equipment into its WBGT guidelines, given the substantial extra heat stress that they generate.

20. The Panel also notes that the ADF has promulgated a generic set of work-rest guidance for their ground forces but has a more demanding work-table customised for their Special Forces. The SAF may wish to promulgate customised work tables for certain groups of personnel as well. This could take the form of a more demanding work-rest cycle for the Special Forces, like the ADF's, or a less demanding work-rest cycle for first year soldiers, in view of their higher susceptibility to heat injuries.

21. Finally, the Panel wishes to highlight an important limitation of the WBGT. In conditions where high humidity or low air movement restricts the evaporation of sweat, people will experience higher levels of heat stress than what the WBGT would suggest<sup>12</sup>. Commanders need to be aware of this limitation when operating in high-humidity and still-air conditions, for example, in a jungle. They must also remain vigilant when operating in the WBGT White and Green zones, because humidity is usually highest at night and in the mornings, when WBGT readings tend to be lowest.

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<sup>12</sup> Grahame M. Budd. Wet-Bulb Globe Temperature (WBGT) - Its History and Its Limitations. *Journal of Science and Medicine in Sport* 2008; 11: 20 – 32.

## *Extending the Use of During-Activity Cooling*

22. The Panel was informed that the US Army and ADF have been implementing a during-activity cooling regime, known as the Arm Immersion Cooling System (AICS). This entails getting soldiers who are training in hot conditions to immerse their arms in cool water (recommended 10°C temperature) during rest breaks. The effectiveness of this measure is documented in the article “*Extremity Cooling for Heat Stress Mitigation in Military and Occupational Settings*”, which was published in the *Journal of Thermal Biology* 38 (2013): 305–310.

23. The Panel understands that the Army promotes arm immersion as a best practice which units may choose to implement. It has been selectively used during strenuous training in units like Basic Military Training Centre, Specialist Cadet School and Officer Cadet School. Given its documented effectiveness and acceptance by US and Australian forces, forces, the Panel recommends that the SAF move towards full-scale implementation of this measure.

## *Setting Upper Hydration Limits*

24. Ensuring adequate hydration is a key measure in the prevention of heat injuries. The Army places strong emphasis on hydration and is conscientious in its efforts to ensure that soldiers consume sufficient water before and during high intensity training. Special attention is paid to first-year soldiers, who have historically been shown to be more vulnerable to heat injuries. These soldiers are subject to a more stringent hydration regime compared to the rest of the Army.

25. There is, however, very little mention of over-hydration, which could also lead to injury or death. In contrast, all the foreign military guidelines that we reviewed emphasise both over-hydration as well as under-hydration. For example, NATO<sup>13</sup> specifies an upper limit of 1.5 litres of water per hour and 12 litres of water per day as a safeguard against water intoxication. In addition, a study covering local long distance races found that there were more cases of over-hydration than dehydration<sup>14</sup>, which suggests a lack of awareness of the dangers of over-hydration. The Panel therefore recommends that the Army promulgates upper hydration

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<sup>13</sup> NATO-TR-HFM-187, Management of Heat and Cold Stress Guidance to NATO Medical Personnel.

<sup>14</sup> Desmond Wei Tan. Body Mass Changes across a Variety of Running Races Distances in Tropics. *Sports Medicine – Open*; 2016: 1-8.

limits to raise awareness that drinking too much could also be dangerous and potentially fatal<sup>15</sup>.

### *Reducing Barriers to Self-Reporting and Speaking Out*

26. The safeguards that the SAF has put in place often depend on soldiers speaking out when they have safety concerns. The onus is also on them to sound out if they or their buddies are feeling unwell. While soldiers are expected to take responsibility for their own safety, Panel members feel that many soldiers may be reluctant to opt out for a variety of reasons. These could include individual volition, peer pressure, coercion (perceived or real), fear of failing a course or desire to avoid weekend make-up training. The Panel's view is supported by the Army's finding that many heat injury cases arose as a result of over-zealous soldiers pushing themselves beyond their limits. The Army would need to address the barriers that are discouraging soldiers from self-reporting if they are feeling unwell. More broadly, the Army should encourage a safety culture where reporting of safety concerns is an individual and corporate responsibility. The SAF could also learn from hospital programs that incorporate Safety Time-outs before every training session and a Speak Out protocol to encourage junior staff to voice out safety concerns.

## Ensuring Early Recognition and Evacuation

### *Recognising Heat Injuries Early*

27. The Panel feels that early recognition of heat injuries is the most important element of our recommendations. The Panel would like to emphasise that commanders, conducting staff and soldiers all have key roles to play in recognising and detecting signs and symptoms of heat injury in their fellow soldiers. They should then take appropriate action to ensure that first aid is rendered and casualties are evacuated as soon as possible. More attention should also be paid to outliers who have difficulty coping with strenuous activity and personnel with heat injury risk factors.

28. A change in the mental status of a casualty is a key manifestation of heat stroke. To assess the casualty's mental state, medics are trained to use the Glasgow Coma Scale (GCS)<sup>16</sup>. A GCS score of less than 14 is the criterion for evacuating a casualty to a medical facility. While GCS is an

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<sup>15</sup> Garner JW. Death by Water Intoxication. Mil Med 2002 May; 167(5): 432-4.

<sup>16</sup> The Glasgow Coma Scale is a scoring system used to describe the level of consciousness in a person following a traumatic brain injury. The GCS estimates coma severity based on Eye Opening (4), Best Verbal Response (5) and Best Motor Response (6) criteria. A GCS score of <14 warrants immediate evacuation of the casualty.



accepted tool for field application, it is challenging to apply and time consuming. It requires someone to make an initial decision to activate a medic, who then has to get to the scene and evaluate the casualty. This could lead to delays in diagnosis, treatment and evacuation. The Panel, therefore, recommends introducing the AVPU<sup>17</sup> scale, which is simple enough to be taught to commanders and safety officers so they can recognise signs of heat injury.

29. The Panel also recommends that heat cramps and heat syncope should be recognised as categories of heat injury and not just as symptoms. These forms of heat injury are already included in the SAF-MOH Clinical Practice Guidelines 1/2010 and various foreign military regulations. The US Marine Corps, for example, classifies heat cramps as a type of heat injury and prescribes that affected soldiers should stop training and slowly re-hydrate<sup>18</sup>. The SAF should, likewise, include the symptoms and treatment of heat cramps and heat syncope in PM-20 and TSR Chap 3. Treating these forms of heat injury correctly would potentially reduce the number of cases deteriorating into heat exhaustion or heat stroke.

30. It is difficult to accurately determine the degree of heat injury in the field. It is, therefore, important for commanders to err on the side of caution. Any casualty who is not fully alert or responding normally should be treated as a heat injury case. Medical staff should be activated quickly to evaluate him/her and initiate treatment. When in doubt, suspected heat stroke cases should be evacuated to a medical facility as soon as possible, so they can receive further assessment and treatment.

### *Improving Temperature Taking in the Field*

31. Precautionary temperature-taking is a significant part of the Army's heat injury management system. The Army's temperature-taking routine is more stringent than what is practiced in other armed forces or in industry, and should serve to filter out significant numbers of potential heat injury cases. Soldiers should, however, be reminded that temperature taking must be done properly in order to be effective.

32. Once a heat injury has occurred, the most accurate way to determine the casualty's core temperature would be to measure his rectal temperature. As this would be impracticable during field training, the

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<sup>17</sup> The AVPU scale (Alert, Response to Verbal Stimuli, Response to Pain Stimuli and Unresponsive) is a system which is taught to healthcare professionals and first aiders on how to measure and record the casualty's level of consciousness.

<sup>18</sup> Marine Corps Order 6200.1E, Heat Injury Prevention Program, describes the signs and symptoms of heat cramps and prescribes that affected soldiers should stop training and slowly drink at least one full canteen.

Panel recommends providing cover medics with tympanic thermometers, which would provide a more accurate assessment of a soldier's core temperature than oral thermometers.

33. There have been calls from some members of the public for the Army to employ wearable technology to measure a soldier's vital signs and warn against the onset of heat stroke. The Panel feels that the range of consumer wearables currently available in the market would not be effective for measuring core temperature in exertional settings. The main utility of such devices would be to monitor and improve soldier performance over time, rather than to detect heat injury.

34. The Panel notes that the Army has commissioned two studies involving the use of wearable technology to improve heat injury management. The first initiative seeks to accurately predict all-cause injury risks by using wearables to detect skin temperature, heart rate and changes in heart rate. The second study seeks to estimate body core temperature using heart rate and chest temperature. If successful, these projects would help overcome the current shortcomings of consumer wearables.

## Providing Effective Cooling to Heat Injury Casualties

### *Refining Current Heat Injury Treatment Protocols*

35. The Panel would like to emphasise that the treatment of heat casualties involves three key principles, which are: (1) rapid cooling of the body core temperature as quickly as possible; (2) stabilising the casualties and evacuating them to hospitals as early as possible; and (3) continued cooling of the casualties while en-route.

36. Body Cooling Units (BCU) are currently deployed in 30 SAF medical centres and are the main cooling modality for treating heat injury casualties in the SAF. They are also used in three restructured hospitals<sup>19</sup>. The Panel recommends that the SAF promulgates a standardised heat injury treatment protocol to guide MOs in using the BCU. The protocol should articulate the achievement of required therapeutic targets such as rectal temperature and blood pressure, and advise MOs on the advance life support measures that must be taken concurrently during cooling. This is to prevent a situation in which MOs, preoccupied with the cooling process, fail to recognize other life-threatening conditions associated with heat stroke (such as seizure, airway compromise or cardiac arrest). The protocol

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<sup>19</sup> Singapore General Hospital (SGH), Changi General Hospital (CGH) and Ng Teng Fong General Hospital (NTFGH).

must also give clear instructions on the criteria for evacuation, weighing the balance between the achievement of therapeutic targets and potential deterioration of the affected servicemen despite best efforts at cooling.

37. The Panel further recommends a review of the BCU treatment protocol that has been designed for senior medics and paramedics when there are no MOs present. The protocol should include clear instructions on escalation to the next echelon whilst undergoing cooling treatment; securing airway, breathing, circulation (ABC); and emphasis on early evacuation to hospital for further treatment.

38. HQ MC should also clarify the procedures for rendering medical aid to female heat injury casualties. The SAF's first aid guidelines for heat injuries include removing all clothing less undergarments and applying ice packs directly to the skin at 6 vital points (neck, armpits and groin). At medical centres, the protocol includes using a rectal thermometer to measure the casualty's temperature. Clarifying the treatment norms for female casualties and providing guidance, if any, on modesty considerations would help reduce doubt or hesitation on the part of first-aiders and medical staff.

39. The Panel recommends that HQ MC sets up formal escalation channels so that MOs can seek guidance and advice from senior SAF physicians when handling medical emergencies. This is similar to the arrangement in the Emergency Departments of restructured hospitals, where senior physicians are available 24/7 for consultation. For the SAF, the escalation channel could be in the form of a 24/7 on-call medical advisory hotline, which is similar to the arrangement already in place for cover medics. HQ MC could also look into working out an arrangement with restructured hospitals for civilian doctors to provide additional advice to augment the SAF's senior medical specialists.

40. After refining its heat injury treatment protocols, the SAF should engage the restructured hospitals to work out coordinating instructions for the transfer of casualties. This is to facilitate a seamless transition of patient care from the SAF's medical centres to the hospitals' emergency departments.

### *Investing in Other Rapid Cooling Methods*

41. While the BCUs have served the SAF well, research suggests that there are newer and more effective cooling methods available. The Panel recommends that the SAF should conduct a full evaluation of the following methods, with a view to augmenting or eventually replacing the BCUs.

a. Cold Water Immersion. Cold Water Immersion (CWI) is the cooling method currently advocated by the US, UK and Australian Armed Forces. It has also been used at large scale sporting events, such as marathons, for on-site cooling of heat casualties before transfer to a medical facility. A group of US emergency and sports medicine experts, comparing various cooling modalities, found that CWI has the highest documented cooling rate for the reversal of hyperthermia.<sup>20</sup>

b. Cooling Suits. Wrap-around cooling suits are another effective way to achieve rapid cooling. These suits reduce core temperature by conduction, as compared to the BCU, which relies mainly on evaporation. A study by a team of DSONL scientists found that commercially-off-the-shelf portable cooling systems such as ThermoSuit® (TS)<sup>21</sup> and EMCOOLS Flex.Pad™<sup>22</sup> were superior to the BCU.<sup>23</sup> Other types of wrap-around suits for rapid cooling include CarbonCool<sup>24</sup>, a wearable surface cooling device used in the emergency departments of SGH, CGH and NTFGH, as well as hospitals in Japan, South Korea, Philippines, India and Malaysia. A further advantage of such suits is that it would be easier to monitor and treat heat casualties while they are being cooled, as compared to if they are undergoing BCU or CWI treatment.

42. Portable Cooling Equipment. The SAF should also look into investing further in portable cooling equipment. While the six ambulances contracted under the Emergency Ambulance Service (EAS) are equipped with EMCOOLS, the same level of treatment is not available in SAF ambulances and safety vehicles. Without EMCOOLS, en-route cooling would be done using ice packs, which is constrained by the limited body surface area that can be cooled. The SAF could enhance en-route cooling in its ambulances and, potentially, on-site cooling in the field as well, if it acquires more of such portable cooling equipment. This would also allow HQ MC to consider sending heat injury casualties direct to hospital, rather

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<sup>20</sup> Luke N Belval. Consensus Statement – Prehospital Care of Exertional Heat Stroke. Prehospital Emergency Care Journal, May/June 2018; volume 22, number 3: 392-397.

<sup>21</sup> TS is a patented whole-body suit designed to cool the body via convective-immersion surface cooling. The system comprises an inflatable mould that holds a supine casualty. Ice water is circulated through the suit by a pump controller.

<sup>22</sup> EMCOOLS utilises the HypoCarbon® technology – a patented material made up of graphite and water, and possess 58- and 15-fold greater thermal conductivity than water and ice respectively. The latex pads are non-toxic and easy to apply onto the skin. EMCOOLS extracts heat from the body via conduction.

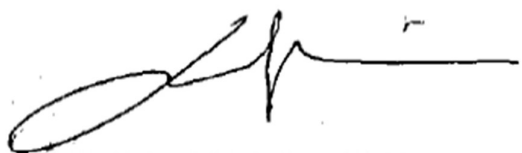
<sup>23</sup> Portable Cooling Systems for Emergency Ambulance Service – DSO National Laboratories, D1 Project Report dated 5 Mar 15.

<sup>24</sup> CarbonCool, a non-invasive surface cooling device via graphite-water filled pads in an insulating suit, is used in the hospital's emergency department for rapid cooling of heat casualties, achieving cooling rates of 3.4°C/hour.

than to a medical centre for BCU cooling first. This may reduce delays in treatment, while maintaining cooling throughout the transportation period.

## CONCLUSION

43. The SAF has invested substantial effort and resources towards heat injury prevention and treatment. The resultant heat injury measures are generally sound and aligned with prevalent industry and foreign military practices. There is, however, scope for further improvement and the Panel has surfaced several recommendations for the SAF's consideration. We hope that these recommendations will help the SAF fine-tune its heat injury prevention measures, ensure early recognition and evacuation of heat injury cases, and provide casualties with more effective rapid cooling.



A/PROF MARK LEONG  
Chairman, ERPHIM

### Members of ERPHIM:



A/PROF MARCUS ONG



A/PROF KELVIN CHEW



DR TEOH CHIN SIM




A/PROF JASON LEE

### Annex:

A. Members of the ERPHIM

**MEMBERS OF THE EXTERNAL REVIEW PANEL ON HEAT INJURY MANAGEMENT**

<b>EMERGENCY MEDICINE</b>	
1	<div style="text-align: center;"></div> <p><b>Assoc Prof Leong Kwok Fai, Mark (Chairman ERPHIM)</b></p> <ul style="list-style-type: none"><li>• Deputy Chairman, Emergency Medicine Academia Clinical Program, SingHealth Duke NUS Academic Medical Centre</li><li>• Senior Consultant, Department of Emergency Medicine, SGH</li></ul>
	<p><b><u>Credentials</u></b></p> <ul style="list-style-type: none"><li>• Clinical Associate Professor, Yong Loo Lin School of Medicine, NUS</li><li>• Adjunct Associate Professor, Duke-NUS Medical School</li><li>• Programme Director, SingHealth Emergency Medicine Residency Programme</li><li>• Previous appointments include:<ul style="list-style-type: none"><li>- Head, Department of Emergency Medicine, SGH</li><li>- Senior Consultant, Disaster Medicine and Operations Readiness Division, MOH</li><li>- Field Medical Commander, Disaster Site Medical Command, MOH</li><li>- Founding Member, Hazmat Medical Life Support Programme, MOH</li></ul></li></ul>

## EMERGENCY MEDICINE

2



**Assoc Prof Ong Eng Hock,  
Marcus**

- Senior Consultant, Department of Emergency Medicine, SGH
- Clinician Scientist, Department of Emergency Medicine, SGH

### Credentials

- Director, Health Services Research Center, Singhealth
- Vice Chair of Research, Emergency Medicine Academic Clinical Program
- Senior Consultant, Hospital Service Division, MOH
- Director, Unit for Pre-hospital Emergency Care, MOH
- Assoc Professor, Duke-NUS Medical School
- Associate Director, Duke-NUS Medical School, Health Services and Systems Research

## SPORTS MEDICINE

3



**Assoc Prof Kelvin Chew Tai Loon**

- Director and Senior Consultant, Changi Sports Medicine Centre, CGH
- Credentials**
- Adjunct Associate Professor, Lee Kong Chian School of Medicine, NTU
  - Ex-co member Special Olympics Singapore, chairman of the Healthy Athletes Programme
  - Chief Medical Officer for the FORMULA 1™ Singapore Grand Prix
  - Member of Federation Internationale de l'Auto (FIA) Medical Commission
  - Previous appointments include:
    - Director, Sports Medicine Centre Alexandra Hospital
    - President of the Sports Medicine Association Singapore
    - Team physician for the Singapore national rugby team
    - Medical director for Standard Chartered Singapore Marathon and Singapore Rugby Sevens



## SPORTS MEDICINE

4



**Dr Teoh Chin Sim**

- Director & Senior Consultant, Sports Medicine Centre, Khoo Teck Puat Hospital

### Credentials

- Chairman, Therapeutic Use Exemption Committee of Anti-Doping Singapore
- Member, the Republic Polytechnic Institutional Review Board and Medical Commission of the Singapore National Olympic Council
- Previous appointments include:
  - Chief Medical Officer (CMO) for Team Singapore 2015 SEA and ASEAN Para Games
  - CMO for 1994 Commonwealth Games
  - CMO 2006 for Asian Games
  - CMO 2012 for Paralympic Games
  - CMO for 2014 ASEAN Para Games
  - CMO for 2014 Youth Olympic Games
  - Secretary of Medical Committee of the International Hockey Federation (FIH)
  - FIH medical officer to the 1999 Champions Trophy and pre-Olympic qualifiers for Sydney 2000
  - President of Sports Medicine Association of Singapore
  - Member, Anti-Doping Committee of the International Paralympic Committee and Therapeutic Use Exemption Expert Group of the World Anti-Doping Agency

## THERMAL PHYSIOLOGIST/RESEARCHER

5



**Assoc Prof Jason Lee Kai Wei**

- Programme Director, Human Performance Programme, Defence Medical and Environmental Research Institute (DMERI), DSO National Laboratories (DSO NL)
- Adjunct Associate Professor, Yong Loo Lin School of Medicine, NUS

### Credentials

- Member, Board of Directors, Singapore Sports School
- Member, Asian Nutrition Society for Sports and Health Executive Committee
- Member, NATO Research Task Group HFM-260
- Member, Sports Safety Committee, Sport Singapore
- Previous appointments include:
  - Member, Institutional Review Board, Singapore Sports Institute, Sport Singapore
  - Member, Soldier Fitness and Health Working Committee, SAF
  - Member, Commando Formation Safety Advisory Board, SAF
  - Member, Heat Injury Prevention Task Force for the SAF
  - Member, Heat Index Guidelines for the General Public, National Environment Agency