

MEETING ABSTRACT

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Heat stress and strain limits applicable to military helicopter aircrew

Andy Weller*, Jonathan Boyd, Ken Puxley

From 15th International Conference on Environmental Ergonomics (ICEE XV)
Portsmouth, UK. 28 June - 3 July 2015

Introduction

Heat stress can result in uncompensated heat storage (termed heat strain and indicated by core temperature, T_C), heat illness, impaired performance and fatigue, and represents a significant threat to the effectiveness of aircrew undertaking hot-weather operations. To determine the potential risk to aircrew, two physiological aircrew simulation trials (1 & 2) were undertaken to assess the environmental heat stress resulting in a mean T_C of 38 °C (occupational limit [e.g. 1]), and the level of parallel heat strain variables.

Methods

In Trial 1, 16 unacclimatised men undertook 4 × 170-minute heat tests in a thermal chamber controlled at wet-bulb-globe-temperatures (WBGTs) of 18, 22, 27 and 31 °C wearing a representative aircrew clothing and equipment ensemble (including body armour). The volunteers were assigned to two groups of 8, with one group completing an exercise protocol representative of the metabolic cost of helicopter pilots (Front) and

the other undertook a rear crew simulation (Rear) (metabolic rate 95 and 117 W.m⁻², respectively). In Trial 2, 8 different men completed the heat test at a WBGT of 28.5 °C. Physiological (rectal temperature, T_{RE} ; mean skin temperature, T_{SK} ; total rate of mass loss, M_{TOT} ; heart rate, HR), and subjective indicators (thermal sensation, TS ; thermal comfort, TC) of heat strain were obtained in both trials.

Results

Mean heat strain responses at 170 minutes in the different thermal environments for Front are given in Table 1. The responses were generally not different between Front and Rear.

Discussion

There was a general curvilinear relationship between WBGT and the heat strain responses. The 38 °C T_C limit was reached at 165 minutes in the 28.5 °C environment and the corresponding increase in HR was consistent with the physiological limit in ISO 9886 [1]. It

Table 1 Mean heat strain responses in the 5 thermal environments

Variable / WBGT (°C)	18	22	27	28.5	31
T_{RE} (°C)	37.5	37.4 ^{ns}	37.7 ^{##}	38.1 [§]	38.5 [¥]
T_{SK} (°C)	34.1	35.2 ^{ΔΔ}	36.4 ^{##}	37.4 ^{§§}	37.3 ^{ns}
M_{TOT} (kg.h ⁻¹)	0.2	0.3 ^Δ	0.4 [#]	0.6 ^{§§}	0.7 ^{ns}
$HR/\uparrow HR$ [vs WBGT 18] (b.min ⁻¹)	88/0	91 ^{ns} /3 ^{ns}	103/14 ^{##}	118/30 [§]	129/41 ^{ns} (p = 0.08)
TS^1/TC^2	1.1/0.5	1.4 ^{ns} /0.8 ^{ns}	2.1 [#] /0.9 ^{ns}	3.0 [§] /2.1 ^{§§}	3.3 ^{ns} /2.1 ^{ns}

¹Thermal Sensation (TS) ratings: 0 (Neutral), 1 (Slightly Warm), 2 (Warm), 3 (Hot), 4 (Very Hot). ²Thermal Comfort (TC) ratings: 0 (Comfortable), 1 (Slightly Uncomfortable), 2 (Uncomfortable), 3 (Very Uncomfortable), 4 (Exceedingly Uncomfortable). Statistical differences between WBGT 18 and 22 (Δ), 22 and 27 (Δ), 27 and 28.5 (Δ) and 28.5 and 31 (Δ) are given by single (P < 0.05) and double (P < 0.01) symbols (Students t tests). ^{ns} signifies no statistical difference.

* Correspondence: asweller@qinetiq.com

Aircrew Systems, QinetiQ, Cody Technology Park, Ively Road, Farnborough, GU14 0LX, UK

remains to be established whether the subjective thermal strain experienced at a WBGT of 28.5 °C (partly driven by high T_{SK}) could influence performance.

Conclusion

Helicopter aircrew are likely to exceed the T_C limit of 38 °C and be at risk of heat-related illness and impaired performance when exposed to a cockpit/cabin WBGT of ~28 °C and beyond.

Acknowledgements

This work was undertaken as part of the Aircrew Systems Research programme and was funded by the UK MOD.

Published: 14 September 2015

Reference

1. ISO 9886:2004 Ergonomics - Evaluation of thermal strain by physiological measurements. International Standards Institution. Geneva, Switzerland. Also published as BS EN ISO 9886:2004 (BSI, UK).

doi:10.1186/2046-7648-4-S1-A26

Cite this article as: Weller *et al.*: Heat stress and strain limits applicable to military helicopter aircrew. *Extreme Physiology & Medicine* 2015 4(Suppl 1):A26.

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