DEFENCE INNOVATION NETWORK

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Defence Innovation Network Grant Scheme: Pilot Project

METABOLIC MEASURES OF SOLDIER HEAT STRESS

PROBLEM

Heat stress and recovery from it has become a major issue in many spheres, for example, in the built urban environment, the outdoor work environment, intensive animal production and wildlife ecology and conservation. Duty-of-care in the workplace and animal production requires prevention of heat stress, effective management and treatment if it occurs and managed recovery. However, our knowledge of the physiological, metabolic, endocrine changes during heat stress and importantly, during recovery is poorly understood. We do not know at what point the body loses thermoregulation and deleterious changes start to occur. The little effective advice that is available has not changed in 40 years.

NEED AND RELEVANCE TO DEFENCE

Heat stress in active soldiers is an operational risk with potentially severe consequences. Military personnel frequently need to operate in environments where there is considerable heat stress and limited opportunity for avoidance (rest, shade). Moreover, they are used to discomfort and often delay reporting symptoms of heat stress. The ideal solution would be a wearable device that informs both the individual and supervising staff of an individual's daily accumulated heat load with alerts for intervention (from rest and cooling, to changed nutrition or paramedical intervention). This might be similar to the dive computers used by scuba divers to inform them of total depth x time and decompression intervals. Devices calculating heat accumulation will not be available until heat load models for specific cohorts (e.g. soldiers) are developed and robustly tested. Currently a Work Table developed within Defence is used as a guideline as to allowable workload in different climatic conditions. However, there are issues around its utility. We quote from a recent paper by a team within the DSTG "The dissociation between symptoms of heat-related illness and body core temperature elevation observed in the present study suggests that the physiological mechanisms underpinning exhaustion during exertional heat stress should be re-examined to determine the most appropriate physiological criteria for establishing work duration limits." (Hunt et al. 2016, TEMPERATURE 2016, VOL. 3, 307–317).

RESEARCH QUESTION

We are proposing a "multi-omics plus" time course study of environmental heat stress and recovery to determine the level of heat accumulated heat load that initiates metabolic changes indicating altered liver and renal function, immune cell changes and alteration to the DNA itself (the methylome). We can also map the path to recovery. A current project has collected an extremely rich and reproducible data set in beef cattle subjected to high heat loads in climate controlled conditions. While cattle are generally not used as a model organism for human studies, there is no widely accepted model organism for heat stress. Rodents are an extremely poor model.

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The data set includes internal body temperatures (at 10 minute intervals), and daily bleeds have enabled full blood biochemistry and haematology, a full plasma metabolomic study, and a methylome study to identify transient or permanent changes to the DNA in response to high heat load. This is a global unique sample and data set involving 120 animals in climate controlled chambers. The value our group brings to the proposed project would be the experience in integrating diverse and intensive time course biological data and building of testable mathematical models to describe responses and recovery. In the second stage, working with collaborators such as Dr Andrew Hunt (DSTG and QUT), we would collect data from a relevant cohort in appropriate conditions with and without an exertional load to adapt and refine the model to this group.

EXPECTED OUTCOME

The outcome would be a heat load model that would be ready for incorporation into a small wearable device to monitor heat load in individuals to assist managing workload and health. Furthermore, by collecting data from individuals, such a system will be able to indicate which individuals that are resilient to heat stress and those that would struggle.