THERMAL MONITORING SYSTEM

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INTRODUCTION

The inability to measure deep body temperature simply and accurately has prevented many potentially informative field studies. A requirement of an ongoing investigation was the ability to monitor the thermal status of saturation divers during their sojourn at 200 msw, while exposed to the helium-oxygen environment in the hyperbaric chamber and bell, and during their daily excursions in water. Due to the unavailability of suitable monitoring equipment commercially, we designed and constructed a thermal monitoring device that would meet the requirements for this and other related projects.

METHODS

The minimum requirement of the project was to monitor core temperature and skin temperature, as well as the temperature of the water perfusing the diving suit. The ability to monitor either heart rate or interbeat interval (R-R interval) was also added as a function.

The thermal monitoring device (TMD) comprises several components (Fig. 1), which are described below.

Core temperature

The method of monitoring core temperature with a radio pill (1, 2, 3) was utilized in the present device. The pill contains a blocking oscillator near-field transmitter powered by a battery. The pill dimensions are 15mm (length) x 6mm (dia.). The electronic circuit is encapsulated in a medical grade epoxy (Hysol), normally used for implantable devices.

Skin and water temperature

The TDM had to be simple to use and require minimal diver intervention. It is for this reason that we excluded the use of sensors attached to the skin; there need to be prepared, attached to the skin and data logger. Instead, two YSI temperature sensors (Yellow Springs Instruments) are incorporated in the walls of the small data logger, which is worn next to the skin of the subject, to receive the transmission from the radio pill. When the

logger is strapped to the torso, the sensor in contact with the skin will reflect skin temperature, whilst of that on the opposing side yields information regarding the temperature of the water perfusing the suit.

Heart rate and R-R interval

ECG is recorded from two leads incorporated into a chest band (Polar). Testing of the first prototype, which transmitted heart rate or R-R interval data by radio frequency, revealed occasional interference between the radio pill and heart rate data. The solution was to redesign the circuitry of the logger, and to have the option of recording ECG with leads connected to the logger.

Data logger

A commercially available physiological data logger (Mini-Mitter Co., Inc.) was modified for the purpose of the present study. The logger has four input channels, two of which are dedicated to monitoring skin and water temperature. An AM receiver unit was incorporated into the logger to receive the pulses emitted by the radio pill; these are converted to TTL pulses, which are then sampled by one channel of the data logger. The logger essentially counts the TTL pulses in a pre-set time interval and stores the information in the random access memory. The fourth channel of the logger is reserved for monitoring ECG. Depending on the sampling protocol, the logger may store heart rate or R-R interval.

In addition to the four channels, the TMD allows the user to record time markers. This is achieved in the present prototype by placing a magnet in close proximity to one of the walls of the logger.

The data accepted by the logger are stored for later retrieval in 256K of memory.

PC interface and sofiare

The TMD is connected to a PC to establish proper functioning of the logger and to initiate the sampling protocol. Once the data collection is complete, a software package (Mini-Mitter Co., Inc.) allows retrieval and graphing of the data.

RESULTS

The prototype TMD was successfully evaluated in a field trial. The initial prototype was placed in a pressure resistant vessel. **A** subsequent version has been packaged in epoxy (Lackwerke Peters GmbH + CoKg) and is undergoing hydrostatic tests and trials in hyperbaric helium-oxygen environments to obtain clearance for use during saturation diving. Its dimensions are 14cm x 6.5cm x 4cm.

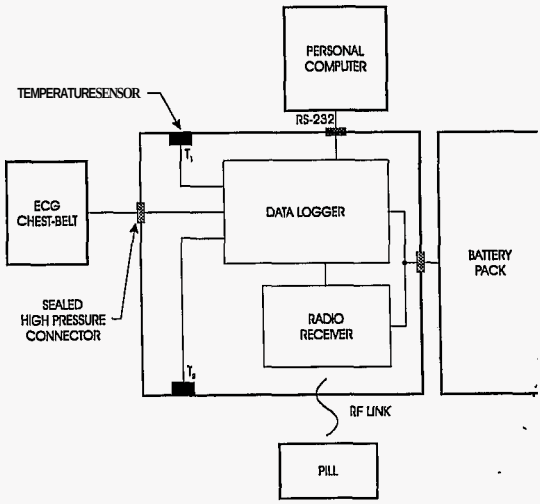

Fig. 1: Schematic diagram of Thermal Monitoring Device

CONCLUSIONS

The earlier developments of diver thermal monitoring equipment by the Defence and Civil Institute of Environmental Medicine (DCIEM) for field use, have regrettably not culminated in a system which would be of practical use for the working diver. The advances in electronic and computer hardware/software have enabled us to develop an accurate yet simple device which may be used in hyperbaric conditions.

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