develop in a particular tissue, resulting in decompression sickness. Hence it is necessary to predict the uptake and elimination of both dissolved and undissolved inert gas in these tissues throughout an exposure to altered environmental pressure.

There are severe difficulties in developing a suitable model because the current end-point in determining the outcome of a decompression trial still depends on the bends incidence and the aviator/diver - doctor interaction which is subjective and imprecise, even when recompression therapy appears to confirm a diagnosis. There is no reliable independent method of inferring the dissolved and undissolved content of a particular tissue or the safe maximum limits relative to the environmental pressure.

Any tissue can be divided into an aqueous and a lipid component, each with a distribution of vascularity such that both diffusion and blood perfusion contribute to the exchange of metabolic gases. The simplest linear model (A), consists of four compartments - two diffusion-limited aqueous and lipid compartments and another two which are perfusion-limited. All four compartments are interconnected and interacting such that the overall tissue response is a quadruple-exponential function.

It can be shown that this four-compartmental model requires at least 14 parameters to describe the overall response to a change in the environmental inert gas pressure. If this tissue contains undissolved gas as well, then it may reasonably be simplified to a two compartment model (B), requiring another 4 parameters.

Assuming that just one compound tissue is involved in the avoidance of an excess of undissolved gas then the results of an experimental series will provide an estimate of the dissolved gas content of only one of the four compartments in model A. The estimate will depend on any undissolved content in one of the compartments in model B. It is known that only two compartments can be determined from data arising in one compartment and thus the 14 + 4 parameters cannot be solved unless data can be extracted independently from another compartment or by using another gas such as helium or neon on a different experiment.

It can be concluded that until some other independent end-point becomes availalbe, it will not be possible to develop a physiologically-based model of decompression. There is no justification for choosing a multi-parameter or multi-tissue model until new experimental data demands it. It is proposed that a best-fit double compartmental model be used for dissolved gas and a single compartment for undissolved gas (4 + 2 parameters). These are the simplest models consistent with the available data. These reduced models do not establish the method of converting a nitrogen response to that of helium or visa-versa.

Because of these limitations an experimental series must be carefully designed to reveal the tolerance of the above models and parameters as well as accumulating statistics.

25 Free flow in a deep diving helmet reduces the dead space to acceptable levels

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One of the most critical characteristics of a diving helmet is the external dead space, which is added to the diver's internal dead space. The possible effects of an increased dead space are increased ventilation, CO_2 retention and finally the risks of intoxication, dyspnea and respiratory muscle fatigue.

To measure the external dead space of a common deep diving helmet (Kirby Morgan Superlite 17) we used a method with a fast mass spectrometer and a respiratory impedance plethysmograph giving a breath by breath analysis. Six divers participated in the study. The divers performed standardised work on a bicycle ergometer just below the surface in an open wet pot. The external dead space at rest was 0.26L BTPS and 0.32L BTPS at moderate work. When a free flow of 9 L/min was supplied to the helmet the external dead space decreased to 0.06 L BTPS and 0.16 L BTPS respectively. When the free flow was further increased to 18 L/min the external dead space decreased to 0.04 L BTPS at rest and 0.08 L BTPS. Two divers decreased their end tidal CO_2 % and four divers decreased (only one significantly) their minute ventilation during moderate work when the dead space decreased.

These results indicate that the free flow should not be reduced below 5-10 L/min to maintain a low dead space.

26 Development of ergonomic design standards for underwater breathing apparatus

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Although recent advances in the knowledge of pressure physiology have resulted in exposure of humans to 65 ATA within hyperbaric chambers, attempts to work underwater have been restricted to shallower depths. The transfer of diving technology from a simulated environment to the ocean is complicated by the remoteness of the worksite and the requirement of adequate life support systems. In particular the design and performance of underwater breathing apparatus is now recognised as a critical factor in underwater work. In order to design breathing equipment to satisfy the divers' needs, it is obvious that respiratory requirements must be identified and the effects of respiratory loading on physiological status must be carefully controlled. Human factors which are of concern to the designer include respiratory heat loss, work of breathing and physical work capacity. At depths greater than 20 meters respiratory heat losses can result in rapid core cooling and bronchial congestion in the absence of active heating of the breathing gas. Maximum ventilation decreases inversely with breathing gas density and may also be limited by breathing apparatus design, leading to respiratory insufficiency. Test procedures traditionally measure only the air flow resistance of the apparatus. Hydrostatic pressure imbalance within the lung-apparatus system can substantially alter internal airway resistance and pulmonary compliance resulting in major changes in the work of breathing. Research suggests that these factors ust be more carefully controlled to ensure safety and comfort of the diver.

In the development of ergonomic design standards for breathing apparatus, items to be specified include gas temperature, work of breathing, ventilation, hydrostatic breathing pressure, respiratory gas mixture and physical work capacity. A number of standards have been proposed, most of which are either concerned with surface breathing apparatus or are based on performance data collected at one atmosphere.Hence factors peculiar to the underwater environment are not addressed. Recently comprehensive guidelines for the performance requirements of underwater breathing apparatus have been published for use in British and Norwegian diving operations. Although testing suggests that it is possible for apparatus to comply with these guidelines, it is probable that only a few of the current products would be acceptable. This paper reviews the actual performance of existing apparatus in relationship to these guidelines and the physiological needs of the diver, and suggests improvements in ergonomic design.

27 Physiological limitations of human performance in hyperbaric environments

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Man has evolved to be able to live and work satisfactorily at one atmosphere absolute pressure and between narrow thermal constraints. The effects on human physiology of exposure to either hyperbaric or hypobaric pressures provide significant limitations to function and to life itself. Indeed it has been inferred that there is no practical working environment with a more severe and complex composite of physiological stresses than that encountered by the modern deep diver in the alien and hostile hyperbaric environment. Every phase of a man's compression, at pressure and decompression has numerous hazards which occur in three main areas: the basic life support systems, the physiological stresses of the special gases and pressure and the special medical factors to individuals who may be living in small confined pressure chambers for as much as 30 days or more and who will require much more time to