Physiological responses to cold exposure in men: a disabled submarine study

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A disabled submarine (DISSUB) lacking power and/or environmental control will become cold, and the ambient air may become hypercapnic and hypoxic. This study examined if the combination of hypoxia, hypercapnia, and cold exposure would adversely affect thermoregulatory responses to acute cold exposure in survivors awaiting rescue. Seven male submariners (33 ± 6 yrs) completed a series of cold-air tests (CAT) that consisted of 20-min at Tair = 22°C, followed by a linear decline (1°C.min⁻¹) in Tair to 12°C, which was then held constant for an additional 150-min. CAT were performed under normoxic, normocapnic conditions (D₀), acute hypoxia (D₁, 16.75% O₂), after 4 days of chronic hypoxia, hypercapnia and cold (D₅, 16.75% O₂, 2.5% CO₂, 4°C), and hypoxia-only again (D₈, 16.75% O₂). The ΔTsk during CAT was larger (p <0.05) on D₀ (-5.2°C), vs. D₁ (-4.8°C), D₅ (-4.5°C), and D₈ (-4.4°C). The change (relative to 0-min) in metabolic heat production (ΔM) at 20-min of CAT was lower (p <0.05) on D₁, D₅, and D₈, vs. D₀, with no differences between D₁, D₅ and D₈. ΔM was not different among trials at any time point after 20-min. The mean body temperature threshold for the onset of shivering was lower on D₁ (35.08°C), D₅ (34.85°C), and D₈ (34.69°C), compared to D₀ (36.01°C). Changes in heat storage did not differ among trials and rectal temperature was not different in D₀ vs. D₁, D₅, and D₈. Thus, mild hypoxia (16.75% FIO₂) impairs vasoconstrictor and initial shivering responses, but the addition of elevated FICO₂ and cold had no further effect. These thermoregulatory effector changes do not increase the risk for hypothermia in DISSUB survivors who are adequately clothed.

Key words
Hypercapnia, hypothermia, hypoxia, shivering, vasoconstriction

Subjective symptoms and postural control during a disabled submarine simulation

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To simulate conditions aboard a disabled submarine, 7 submariners were confined for 5 d to a normobaric environment of 16.75% O₂, 2.5% CO₂, 4°C, and 85% relative humidity (RH). After 2 control days and 1 d of hypoxia, the remaining environmental conditions were imposed for the next 5 d, followed by 1 additional day of just hypoxia. Daily morning symptoms were assessed using the Environmental Symptoms Questionnaire (ESQ). Postural stability was determined on 4 occasions using a computerized balance system: control period, after 2.7 and 4.7 d of steady-state test conditions, and after 5.7 d (with return to normal ambient temp, RH, and CO₂). Three balance tests were performed: eyes open, eyes closed, and a dynamic test. Postural stability deteriorated after 2.7 d (87% eyes open, p <0.001 and 26% eyes closed, p =
0.01). ESQ symptom subsets for acute mountain sickness, exertion, fatigue, alertness, and ear/nose/throat were not significantly different. Cold symptom subsets were increased after 3-7 d (p <0.001); distress and muscle discomfort subsets after 7 d (p = 0.02). Continued exposure to the combination of cold and hypoxia elicited subjective symptom changes and disturbances in postural stability that are statistically significant. These observations may be of practical importance when tasks aboard a disabled submarine involve balance and mobility.

Key words
Hypoxia, hypercapnia, postural control, Environmental Symptoms Questionnaire


Open water scuba diving accidents at Leicester: five years’ experience

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Abstract
Objectives: The aim of this study was to determine the incidence, type, outcome, and possible risk factors of diving accidents in each year of a five year period presenting from one dive centre to a large teaching hospital accident and emergency (A&E) department.

Methods: All patients included in this study presented to the A&E department at a local teaching hospital in close proximity to the largest inland diving centre in the UK. Our main outcome measures were: presenting symptoms, administration of recompression treatment, mortality, and postmortem examination report where applicable.

Results: Overall, 25 patients experienced a serious open water diving accident at the centre between 1992 and 1996 inclusive. The percentage of survivors (n = 18) with symptoms of decompression sickness receiving recompression treatment was 72%. All surviving patients received medical treatment for at least 24 hours before discharge. The median depth of diving accidents was 24 metres (m) (range 7–36 m). During the study period, 1992–96, the number of accidents increased from one to 10 and the incidence of diving accidents increased from four per 100,000 to 15.4 per 100,000. Over the same time period the number of deaths increased threefold.

Conclusions: The aetiology of the increase in the incidence of accidents is multifactorial. Important risk factors were thought to be: rapid ascent (in 48% of patients), cold water, poor visibility, the number of dives per diver, and the experience of the diver. It is concluded that there needs to be an increased awareness of the management of diving injuries in an A&E department in close proximity to an inland diving centre.

Keywords
Scuba diving, decompression sickness, barotrauma, nitrogen narcosis


Editors note: This is one of very few studies in the literature where there is a reasonably accurate idea of the denominator, that is, the size of the total population of diver. This allows a true incidence rate to be derived for fatalities and serious diving injuries.

The database of randomised controlled trials in hyperbaric medicine developed by Dr Michael Bennett and colleagues at the Prince of Wales Diving and Hyperbaric Medicine Unit is at:

<www.hboevidence.com>