

## **OCULAR TEAR FILM BUBBLE FORMATION AFTER BREATH-HOLD DIVING**

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### Introduction

The first well-documented case of decompression sickness was that of a snake, described by Boyle in 1670 (Phil Trans R Soc 1670;5:2011-58). Based on the observation of a gaseous bubble formed in the intraocular fluid, Boyle concluded that bubbles could form in tissues undergoing rapid decompression. More than three centuries later, the formation of tear film bubbles, after both dry-chamber simulated compressed air dives (Mekjavic et al., Undersea Hyperb Med 1998;25:201-10) and in-water recreational compressed air dives (Bennett et al., Undersea Hyperb Med 2001;28:1-7), has been indicated as a sign of decompression stress in humans. Based on these observations, and evidence that a breath-hold diver could undertake profiles sufficient to elicit decompression illness (Paulev, J Appl Physiol 1965;20:1028-31), the aim of the present study was to investigate tear film bubble formation in breath-hold divers.

### Methodology

The surface of the right eye of 17 breath-hold divers was examined and digitally recorded before and after repeated breath-hold excursions to a maximum depth of -28.5m in the Submarine Escape Training Tank (SETT, Gosport, UK). Dive profiles were recorded with wrist mounted personal dive computers (Stinger, Suunto, Vantaa, Finland) and downloaded to PC via commercially available dive software (Dive Manager, v.1.3, Suunto, Vantaa, Finland). Data was manually transferred from Dive Manager to a spreadsheet (Microsoft Excel) and analysed as maximum percent nitrogen saturation via calculations derived from Buhlmann's ZH-L16c algorithm (Tauchmedizin, 1995, 4th ed. Springer-Verlag: Berlin). Grubb's test was used to identify significant differences in dive profile parameters and theoretical nitrogen loads between individuals with and without bubbles present. A stepwise multiple linear regression model was used to determine the relative contribution of number of dives, depth, time at depth, ascent and descent rates to bubble formation.

### Results

Tear film bubbles ( $n = 5$ ) were presented by only one diver, post-dive. The total and average times below -15m for this diver were significantly longer (both  $P = 0.025$ ) than for the non-presenting divers. An analysis of peak nitrogen saturation indicated that the presenting diver had significantly higher saturations in 'tissue' compartments 14-16 of the Buhlmann ZH-L16c model ( $P = 0.046$  to  $0.048$ ). Multiple regression modeling suggested that of all parameters considered, only total time below -15m and average time below -15m had significant predictive power (both  $P < 0.001$ ; 97.1% and 2.7%) for bubble formation.

### Conclusions

It is believed that this is the first time that ocular tear film bubble formation has been reported in breath-hold divers.

Following Mekjavic et al. (1998), it may be suggested that the observation of tear film bubbles could be used as an in-the-field assessment of increasing decompression stress in breath-hold divers.

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