

Observed incidence of decompression sickness and venous gas bubbles following 18m chamber dives on RN Table 11 / Norwegian air diving table.

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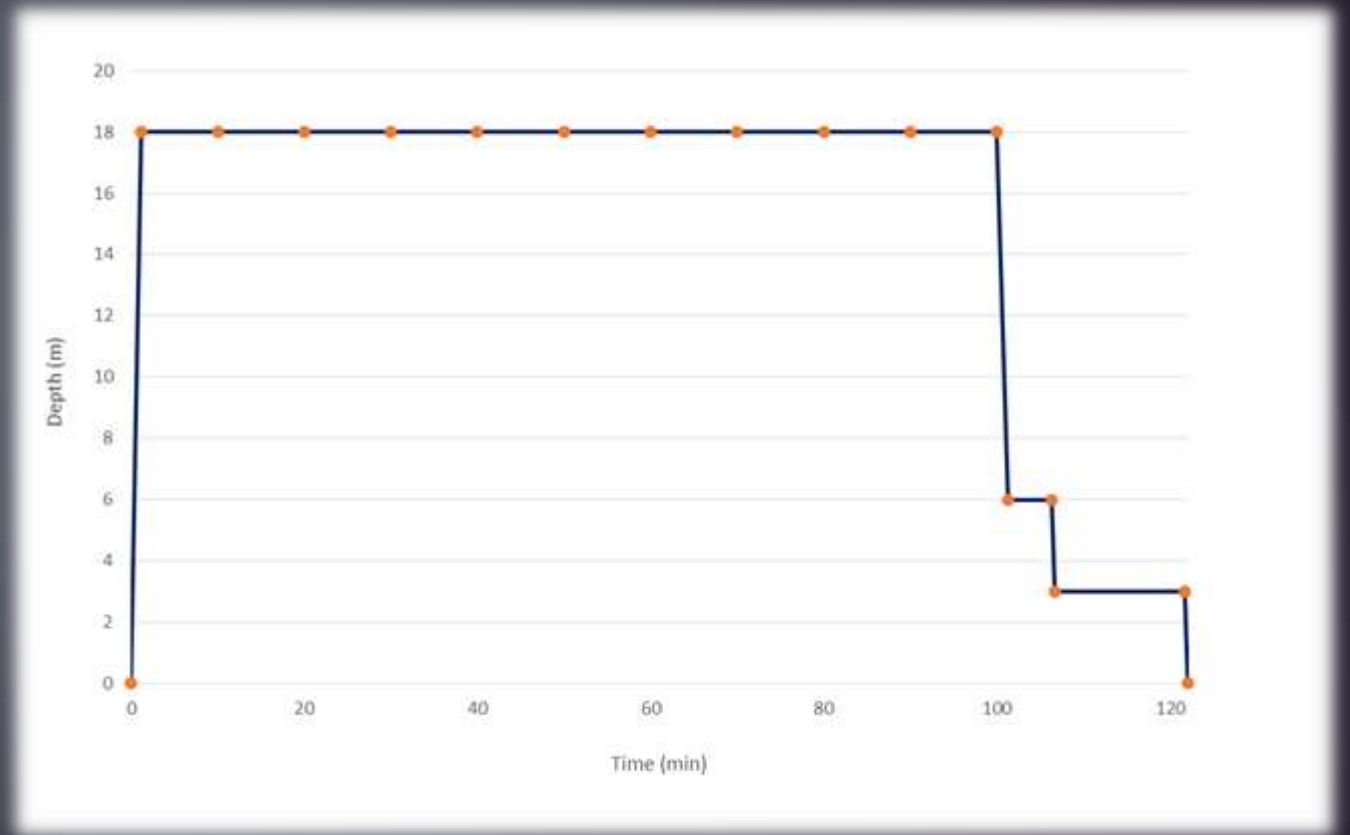
Background

- ▶ Seven studies included - Aim - to test varying interventions/behavioural/environmental changes on post-dive bubbling and decompression sickness (DCS) risk.
- ▶ Not ideal to use DCS as a binomial end point; too many dives needed – high time and monetary cost.
- ▶ Instead, use measureable bubbles as a marker of risk.
- ▶ Need a dive profile that produces bubbles across subjects.
- ▶ Need a 'safe', tested profile – not testing a table. Recent case of DCS has provoked worries that Table 11 is not safe.

Royal Navy Table 11 /Norwegian air dive table

Profile:

- ▶ Descent to 18 m for 100 minutes. Descent rate : 15 m / min.
- ▶ Ascent to first deco stop at 6 m for 5 min, and at 3 m for 15 min. Ascent rate : 9 m / min.
- ▶ Total dive time 122 min.



Methodology

- ▶ Data collected from 7 **dry chamber** dive studies; same operator monitored bubbles in each, using Doppler (n=6) or echocardiography (n=1).
- ▶ **219** dives included; test and control data.
- ▶ Bubble measurements began 5 min post dive; at 5 min intervals for 30 min, 15 min intervals thereafter up to 2 h.
- ▶ Kisman Masurel (KM; Doppler) and Eftedal Brubakk (EB; echo) grading systems used; approximate to each other (Blogg and Gennser, EUBS proceedings 2010).
- ▶ Test interventions included nitric oxide, exercise regimens, bed rest, dehydration regimens and multi-day diving.

Results

Resting	Doppler	Doppler	Doppler	Doppler	Doppler	Echo	Doppler
	NO trial	Bed Rest	Dehydration 1	Exercise 1	Exercise 2	Multi-day	Dehydration 2
N = 219	n = 18	n = 50	n = 24	n = 30	n = 45	n = 37	n = 15
Med Median*	0.5	0	0	1.25	1	1	0
Med Maximum~	2.66	0	1	3	2	3	0
Range	0 – 3.33	0 – 3.33	0 – 3.33	0 – 3.33	0 – 3.66	0 – 4	0 – 3.33
DCS?	No	No	One 'niggle'	No	No	Yes - 1	One 'niggle'
Overall (N = 219) median median = KM / EB 0, overall median maximum = KM / EB 2							

* Total median – calculated by taking the median after each individual dive in a series, then deriving the overall median of those values.

~ Total median maximum – calculated by taking the maximum after each individual dive, then deriving the median of those maximum values.

N.B. Doppler KM grades should be denoted using Roman numerals to represent ordinal data, but for clarity are decimalised, e.g. 3.33 is equivalent to KM III+

Results - Incidence of DCS

- ▶ **One case of DCS** (from the multi-day study)
- ▶ Presented as ankle pain initially, then progressed to CNS bend (see poster by Møllerlækken et al for case study).
- ▶ Two 'niggles' – both shoulder discomfort that resolved without hyperbaric treatment.
- ▶ **Incidence of DCS of 0.49% (± 0.92 @ 95% CI)**
- ▶ If niggles included, then incidence of DCS of 1.4% (± 1.53 @ 95% CI)

Discussion – Bubble grades

- ▶ Profile produced bubble grades from 0 to KM IV- and EB 4 (both one grade below maximum on each scale).
- ▶ Median grades for each trial (n = 7) ranged from 0 – 1.25. Median maximum grades ranged from 0 – 3.
- ▶ In a DCIEM study where bubble grade and DCS risk has been correlated (N = 1726) (Sawatzky 1991), DCS incidence rose from 1.1% with maximum grade KM 2, to 6.3% with max KM 3.
- ▶ From 219 dives, overall median = 0, overall median maximum = 2, so this profile would fit into lower risk category by comparison.
- ▶ **Good for intervention trials – range of bubble loads are ideal.**

Discussion – Profile Safety

- ▶ From 219 dives, incidence of DCS was 0.49% - low risk.
- ▶ The USN 93 probabilistic model predicts a risk of DCS of 3.7% for this profile (Thalmann ED., Undersea Hyperb Med 24, 255 – 274, 1997).
- ▶ pDCS for USN Table 56 (18m/100min, total deco 15 min) calculated at 3.2 – 3.8% dependent on model used (BVM(3) and NMRI98 respectively (Gerth WA, Doolette DJ. NEDU TR 07-09, Panama City, FL, 2007).
- ▶ Even with niggles included, then incidence of 1.4%
- ▶ Royal Navy dive manual (BR2806) refers to this profile as 'normal exposure where the risk of DCS is negligible'.
- ▶ Often concern after a bend, but these figures should help alleviate that.

Summary

- ▶ Recent worries following a moderately severe DCS incident that this profile is high risk.
- ▶ Data from these 219 dives suggest that the DCS risk is still below that predicted by models for this profile.
- ▶ Observed DCS – data showed an incidence of 0.49% with an overall median maximum bubble grade of 2; this is comparable with the DCIEM data (N = 1726) where those with maximum KM grade II bubbles had an DCS incidence of 1.1%.
- ▶ The profile is bubble producing (wide range from no bubbles to one grade less than maximum).
- ▶ Useful profile for studies where bubbles used to infer DCS risk.

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