ENVIRONMENTAL FACTORS ASSOCIATED WITH BUOYANCY PROBLEMS, OUT-OF-AIR AND RAPID ASCENT

Buzzacott PL[1,2], Dunford R[1,3], Denoble PJ[1,3], Vann RD[1,3].
[1]Divers Alert Network (DAN), Durham NC, [2]School of Population Health, University of Western Australia, Perth WA,
[3]Department of Anaesthesiology, Duke University Medical Center. Durham, NC

INTRODUCTION

- Among recreational scuba divers the three leading causes of injury and death are drowning/near-drowning, barotrauma due to expanding air during ascent and decompression illness (DCI).
- Running out of air, buoyancy problems and ascending rapidly are associated with each of these and are thought to often occur concurrently[1-3], suggesting they may share common causes.
- We report environmental factors associated with out-of-air, buoyancy trouble and ascending at a rate >60 ft/min over at least 20ft.

METHODS

- The Divers Alert Network Project Dive Exploration (PDE) collects data from divers regarding dive information, recorded depth-time profiles, and reported problems. Divers are approached at the commencement of a dive series at popular recreational dive sites such as in the Caribbean, Scapa Flow and Grand Cayman and were asked to complete a survey, wear a depth-time logger underwater and to record personal dive history data following each dive.
- Consent was implied by participation and an information sheet supplied.
- From 1991-2004, PDE collected 52,582 recreational dives by 5,046 adult divers.
- Information was collected about the dive platform, gas breathed, diving dress, thermal comfort, workload, and incremental depth-time readings.
- Rates of ascent to the surface were calculated from recorded profiles.
- Dives where a problem was reported (cases) were compared to dives made by the same divers in which that problem was not reported (controls).
- Intra-dive differences between case-dives and diver-matched control-dives were tested for significance ($p \leq 0.05$) using a logistic regression model with backwards elimination.

RESULTS

- Running out of air was reported during 89/1,333 dives (6.7%), buoyancy problems during 368/3,459 dives (10.6%), rapid ascent during 301/2,831 dives (10.6%) and ascent rate >60ft/min physically recorded over 20 feet or more during 243/1,975 dives (12.3%).
- Running out of air involved dives that were deeper (OR 1.02 per ft, 95% CI 1.01, 1.02), shorter (OR 1.02 per min, 95% CI 1.00, 1.04), from a charter-boat or live-aboard rather than shore or small craft (OR 3.88, 95% CI 1.89, 7.94) and a reported more strenuous workload (OR 3.72, 95% CI 1.50, 9.26).
- Buoyancy problems were associated with dives that were shorter (OR 1.03, 95% CI 1.02, 1.04), from a charter-boat or live-aboard rather than the shore or small craft (OR 1.40, 95% CI 1.03, 1.90), involved breathing air rather than nitrox (OR 2.3, 95% CI 1.6, 3.3) and a more strenuous workload (OR 2.04, 95% CI 1.16, 3.60).
- Dives when rapid ascents were reported more likely involved dives that were shallower (OR 1.01, 95% CI 1.01, 1.02), shorter (OR 1.03, 95% CI 1.02, 1.04), from a charter-boat or live-aboard rather than the shore or small craft (OR 1.82, 95% CI 1.14, 2.91) and a reported more strenuous workload (OR 8.77, 95% CI 5.52, 13.89).

RESULTS Continued…

- Dives when a rapid ascent was recorded more likely involved dives that were shallower (OR 1.01, 95% CI 1.01, 1.02), shorter (OR 1.05, 95% CI 1.04, 1.06) and from a charter-boat or live-aboard rather than shore or small craft (OR 2.36, 95% CI 1.58, 3.53).
- Of 243 dives where a rapid ascent was recorded four (2%) also reported running out of air or losing buoyancy control, and just 28 (12%) reported the rapid ascent.

CONCLUSIONS

- Dive platform and perceived workload were strongly associated with risk factors for diving morbidity and mortality, whilst depth and the linked co-variate *time* were also (weakly) associated.
- Divers under-reported rapid ascents, perhaps not defining ascents as rapid using the same criteria as our study (>60 ft/min over 20ft).
- We recommend scuba diving instructors give greater emphasis during training to monitoring gas reserves, buoyancy control and the importance of slowing ascents, and that commercial dive boats consider the anticipated workload when selecting a dive site.

Table 1: Dive characteristics for each of the four morbidity/mortality risk factors

	Running out of Air (n = 89/1,333 dives by 69 divers)	Buoyancy Problem (n = 368/3,459 dives by 239 divers)	Reporting Rapid Ascent (n = 301/2,831 dives by 245 divers)	Recording Rapid Ascent (n = 243/1,975 dives by 195 divers)
Depth ft (SD)	73.8' (27.0) Vs 64.4' (23.8)	67.3' (23.9) Vs 70.0' (24.9)	70.3' (25.6) Vs 78.0' (27.7)	66.6' (23.0) Vs 73.3' (27.0)
Dive time mins (SD)	45.8 (14.6) Vs 50.1 (14.2)	45.4 (13.3) Vs 51.8 (13.6)	41.1 (13.3) Vs 46.2 (14.3)	33.7 (15.1) Vs 42.8 (14.1)
Ascent rate ft/min (SD)	24.0 (19.3) Vs 19.3 (17.2)	21.0 (26.0) Vs 16.1 (16.4)	28.8 (26.6) Vs 20.1 (15.6)	82.2 (32.4) Vs 26.6 (17.2)

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