REVIEWING THE SAFETY OF DIVE COMPUTERS

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Over the past few years the market has been flooded with various models of dive computer. They have been promoted heavily by the manufacturers, distributors and dive shops, each extolling the virtues of the particular unit they are promoting. In their enthusiasm, many of these eager proponents of dive computers lost sight of the fact that, in reality, very little is known about how well the various units would perform, or were already performing, in this field.

Dive computers are programmed with various mathematical models (i.e. sets of mathematical equations) which are designed to simulate the uptake and release of nitrogen within a diver's body, but most of these models had little or no field testing before the computers were released onto the market. No-one could be sure how well these devices would do the main job they were designed for, to prevent decompression illness, specifically that syndrome known as decompression sickness (DCS).

However, these magic little boxes captured the imaginations of many divers throughout the world and many millions of dives have now been done with various units. As data of the DCS incidence comes in we can get a better idea of how safe the units are.

From mid 1988 to the end of 1989, 168 cases of DCS in divers using computers were reported to the Divers Alert Network (DAN) in the USA. One hundred and twenty six of these occurred in 1989 alone, which represents about 32% of the reported DCS cases that year.[1]

An analysis of the DAN statistics for 1987 and 1988 showed that those divers using computers were diving deeper than those using table.[2,3] In addition, it appeared that computer-users seemed more likely to get the bends after multi-level dives and decompression stop dives. Although computer-users also had a higher bends rate after repetitive dives, the difference was not statistically significant. The 1989 DAN statistics show that 81% of the computer-users who got DCS that year had dived deeper than 24 m and 73% of them had made repetitive dives. The 1989 DAN data appear to indicate that computer-users have a higher DCS incidence after deeper dives or repetitive dives than do table-users. This data is presented in Table 1.

British Sub-Aqua club (BS-AC) data indicate that, in the United Kingdom in 1987, 16% of the divers treated for DCS had been diving within the limits of their dive computer.[4] BS-AC data for 1989 indicate 33% (45/137) of the British divers who got DCS had been using a dive computer.[6] However, only 15 of these reported diving within the limits of their units. When six of these 15 divers were medically examined, five were found to have a patent foramen ovale which possibly predisposed them to bends. Preliminary data of diving incidents in Britain in 1990 indicates that 21% (17/80) of the divers who suffered DCS that year had dived within the limits of their computers.[7]

Analysis of the British data shows that the vast majority of the bends cases in computer users occurred after dives deeper than 30 m.

On a brighter note, a recently released report provides details of a total of 44,277 dives done using computers, all conducted from a particular cruise vessel.[8] There was only one reported case of DCS in a computer-user, and this diver had misused his computer. About 70% of these dives were done using Dacor "MicroBrains", which utilise a decompression model which is reasonably conservative in most situations.

No data is currently available for the comparative incidence of bends in computer-users and table-users in Australia as a whole. However, although the numbers are growing steadily, relatively few Australian divers own a dive computer.

So, divers can, and do, get DCS using dive computers. Since it is unlikely that around 20-30% of active divers use a dive computer, the DCS incidence in computer-users may be disproportionately high, but this has not been confirmed. Sometimes DCS results because the diver disobeys the advice given by the computer. On other occasions divers have suffered from DCS after diving well within the limits of the computer. Table 2 shows the no-stop limitsof some computers and the DCIEM and USN tables. Note that some are much more conservative than others. The decompression models programmed into the computers cannot completely predict the gas flow in and out of our actual body tissues. Our physiology is not always so predictable as many factors influence the rate of gas uptake and elimination and the possibility of consequent decompression sickness.

From my own observations it appears that many divers who own a computer seem to dive more frequently, often greatly extending their dive time during a dive, and doing more repetitive dives. If true, this, in itself, would put a computer-user at a greater risk of DCS. High risk dive profiles for computer-users (and, in most cases, table-users) include deep dives, especially deep repetitive dives, decompression stop dives, multi-day repetitive dives and multi-level dives in which a diver descends deeper, rather than working shallower, during the dive.

Armed with the knowledge gained over the past few years, those who programme these computers now have a better idea of shortcomings of their models and some have taken very significant steps to improve the safety of their products. Some of the computers have relatively recently become more conservative in the no-decompression stop

TABLE 1

DAN DATA ON DIVE PROFILES OF DCS CASES 1988 AND 1989

	1988		1989	
Dive Profile	Tables	Computers	Tables	Computers
Deeper than 24 m	67.0%	81.0%	38.5%	81.0%
Rectangular	42.0%	61.0%	53.2%	28.6%
Multi-day	48.0%	55.0%	48.3%	52.4%
Repetitive	57.0%	81.0%	58.5%	73.0%
Single day	52.0%	45.0%	51.7%	47.6%

Note: There was a certain amount of overlapping of various categories. For example, some divers may have done a repetitive, rectangular dive deeper than 24 m.

TABLE 2

NO-STOP LIMITS FOR SOME DIVE COMPUTERS AND TWO TABLES

Depth (m)	Aladin Pro	Datamax Sport	DC-11	MicroBrain Pro Plus	Skinny-dipper*	Solution	SME-ML	DCIEM Tables	US Navy Tables
9	354	260	215	220	225	222	215	300	-
12	121	136	93	106	133	127	132	150	200
15	70	78	58	64	75	72	74	75	100
18	49	55	36	44	52	52	53	50	60
21	35	40	22	31	39	37	38	35	50
24	25	31	15	20	31	29	29	25	40
27	20	25	12	15	24	23	23	20	30
30	16	20	9	12	19	18	18	15	25
33	14	16	8	10	13	13	13	12	20
36	12	13	7	8	10	11	11	10	15
39	10	11	6	7	9	9	9	8	10

* The times for Edge and Dephi should be identical as they use the same algorithm.

times they allow (and decompression stops times they require), especially for repetitive dives. Hopefully the programmers will continue to address more the shortcomings of dive computers, including their current inability to alter the off-gassing rate after a rapid ascent, and, in most cases, introducing more severe penalties for working deeper during a dive, or in subsequent dives. I have little doubt that these problems will eventually be addressed and the units will continue to improve in leaps and bounds in the future. Tables 3-5 show comparisons between various dive computers and tables for certain dive profiles. As can be seen there are wide variations in the times allowed and the decompressions required.

During another, otherwise identical, series of tests to those in Table 3 I released the pressure in the chamber to simulate an ascent rate approaching 30 m/minute. All the computers gave the same repetitive dive times as they would have if the correct ascent rate had been adhered to. None of these computers reduced the allowable times for the following repetitive dive(s) to try to compensate for any extra bubble formation occurring as result of a faster than recommended ascent. This emphasizes the importance of not exceeding the ascent rate recommended by the computer.

I believe that a healthy, sensible and knowledgeable diver can usually (but of course not always) use certain dive computers relatively safely on particular types of dives. The diver must be thoroughly educated in the computer's use so that he or she is familiar with the particular computer that he or she is using, aware of the shortcomings of that computer (and they all do have them!) and with the safe diving practices that should be adopted when using a computer.

TABLE 3

DIVE TIMES ALLOWED BY VARIOUS COMPUTERS AND TABLES FOR TWO RECTANGULAR PROFILE DIVES SEPARATED BY A SURFACE INTERVAL OF 60 MINUTES

(Times are given in minutes)

Dive 1	**Depth 36 m**
	Allowable no-deco time
Aladin Pro	12
Datamax Sport	13
DC 11	7
MicroBrain Pro Plus	8
Skinnydipper	11
Solution	11
SME-ML	11
DCIEM Tables	10
US Navy Tables	15
Bottom time	**10**
Ascent time	**3.6**
Ascent rate	**10 m/ minute**
Stops required:	
DC-11	1.8 min at 3 m
MicroBrain Pro Plus	1 min at 3 m
Surface Interval =	**60**
Dive 2	**Depth 30 m**
	Allowable no-deco time
Aladin Pro	15
Datamax Sport	15
DC-11	9
MicroBrain Pro Plus	12
Skinnydipper	19
Solution	17
SME-ML	19
DCIEM Tables	10
US Navy Tables	11
Bottom time	**18**
Stops required:	
Aladin Pro	2 min at 3 m
Datamax Sport	1 min at 3 m
DC-11	1 min at 6 m + 13 min at 3 m
MicroBrain Pro Plus	3 min at 3 m
Skinnydipper	**None**
Solution	1 min at 3 m
SME-ML	**None**
DCIEM Tables	5 min at 6 m + 10 min at 3 m
US Navy Tables	15 min at 3 m
Ascent time =	**2.4**
Ascent Rate	**12.5 m/minute**

TABLE 4

DIVE TIMES ALLOWED BY VARIOUS COMPUTERS AND TABLES FOR TWO RECTANGULAR PROFILE DIVES SEPARATED BY A SURFACE INTERVAL OF 32 MINUTES

(Tmes are given in minutes)

Dive 1	**Depth = 27 m**
	Allowable no-deco time
Aladin Pro	20
Datamax Sport	25
MicroBrain Pro Plus	15
Skinnydipper	23
Solution	23
SME-ML	23
DCIEM Tables	20
US Navy Tables	30
Bottom time =	**18**
Stops required =	**none**
Ascent time =	**3.5**
Ascent rate	**7.7 m/minute**
Surface interval =	**32**
Dive 2	**Depth = 30 m**
	Allowable no-deco time
Aladin Pro	12
Datamax Sport	12
MicroBrain Pro Plus	12
Skinnydipper	16
Solution	13
SME-ML	16
DCIEM Tables	9
US Navy Tables	3
Bottom time	**16**
Stops required:	
Aladin Pro	7 min at 3 m
Datamax Sport	4 min at 3 m
MicroBrain Pro Plus	4 min at 3 m
Skinnydipper	**None**
Solution	11 min at 3 m
SME-ML	**None**
DCIEM Tables	5 min at 6 m + 10 min at 3 m
US Navy Tables	15 min at 3 m

The above dives were conducted in a pressure chamber. When planning dives, a diver should always do the deepest dive first and make subsequent repetitive dives progressively shallower. These simulated dives were conducted in this manner to investigate how the various computers would respond to this particular (undesirable) diving situation.

TABLE 5

DIVE TIMES ALLOWED AT 15 m BY VARIOUS COMPUTERS AND TABLES FOR A SINGLE, MULTI-LEVEL DIVE TO 30 m FOR 5 MINUTES, FOLLOWED BY 20 m FOR 10 MINUTES, FOLLOWED BY ASCENT TO 15 m

(Times given are in minutes)

	No stop time allowed at 15 m
Aladin Pro	41
Datamax Sport	52
DC-11	24
MicroBrain Pro Plus	38
Skinnydipper	48
Solution	45
SME-ML	46
DCIEM Tables	35
PADI Wheel	42

It appears to be important for a diver, whether using a computer or dive tables, to go to the maximum depth early in the dive and gradually, and progressively, work shallower. The ascent rate should never exceed 18 m/minute and should preferably be around 10 m/minute, or slower, when shallower than about 30 m. (Ascent to 30 m from greater depths can be at a rate approaching 18 m/minute). In addition, a diver should endeavour to end all dives with a safety stop somewhere between 3-9 m (preferably at 5-6 m) for at least 3 minutes. These, and other, safe diving practices are summarised below.

Recommended practices for diving with a dive computer

If you are using a dive computer I recommend that you should:

Ascend slowly. Never exceed the ascent rate recommended by the computer, and generally ascend at about 10 m/minute or slower.

Go to the maximum depth early in the dive and progressively and slowly work shallower. End the dive with at least 3 minutes at 3-9 m (preferably at 5-6 m). Avoid rectangular dive profiles.

Do not dive right to the limits given by the computers. They, like dive tables, do not cater for individual susceptibility to bends. Reduce the limits progressively for each dive in a series of repetitive dives. This is especially important when repetitive dives are conducted over multiple days.

Avoid using the computer for deep, repetitive dives, especially those with rectangular profiles and/or those requiring a mandatory decompressions stops(s).

In the event of a computer failure during a dive, immediately ascend slowly to 5-6 m, and spend at least five minutes there before surfacing. If a mandatory stops was indicated before the computer failure and you cannot remember it, spend as much time at around 6 m as possible, leaving enough air to return to the boast safely. Do not reenter the water for at leasts 18 hours, or for the time needed for the dive computer to totally off-gas (had it not malfunctioned), whichever is longer.

If using a dive computer for multi-day, repetitive diving, take a break around the third day to allow your body to rid itself of some of the extra nitrogen load it has accumulated.

Do not begin to use a dive computer if you have dived in the previous 24 hours.

References

1 Divers Alert Network. *1989 Report on diving accidents and fatalities.* Durham, North Carolina: Divers Alert Network, 1990.

2 Divers Alert Network. *Report on 1988 diving accidents*. Durham, North Carolina: Divers Alert Network, 1989.

3 Divers Alert Network. *Preliminary report on diving accidents.* Durham, North Carolina: Divers Alert Network, 1988.

4 Shaw D. NDC diving incidents report. *Proceedings of diving officers' conference*. London: BS-AC, 1987.

5 Allen C. NDC diving incidents report. *Proceedings of diving officers' conference.* London: BS-AC, 1989.

6 Allen C. Deaths down again. *Diver* 1990; 35 (12): 31-32.

7 Gilliam BC. Computer vs. table usage - 12 months' data. *Sources* 1991; 3 (1): 39-41.

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