

## Safe Diving Equals Fun Diving: Prescriptions for Diving Women

Bruce E Bassett, PhD

Formerly Aerospace Physiologist, Lt Col USAF, USAF School of Aerospace Medicine, Brookes AFB, Texas. Now President of Human Underwater Biology Inc, San Antonio, Texas.

This paper was presented at IQ 10/1978 and we are grateful to NAUI for permission to reprint it and the author for offering it to us.

### Susceptibility of Women to Decompression Sickness

The classical publications on decompression sickness (DCS) do not contain any information on the relationship between sex and susceptibility to DCS because of a lack of data regarding exposures of women. Records covering the last ten years of altitude chamber exposures at the USAF School of Aerospace Medicine (USAFSAM) indicate there is statistically significant four fold greater incidence of altitude DCS in women than in men (women 5, 791 exposures; 17 cases DCS, incidence 0.09%. Significance in difference tested by  $\text{Chi}^2$ , P 0.0005).

One additional subgroup with an apparently greater incidence of DCS than the women exposed at the USAFSAM are the female AFA cadets trained at Peterson AFB. However, the numbers in this group are too small for statistical comparisons with any of the other subgroups (female AFA cadets: 155 exposures; three cases DCS; incidence 1.935%)

Additional information and data were obtained from analyses of 104 USAF-wide cases of altitude DCS treated by recompression during the 12 year period from 1966 through 1977. Of these 104 cases, 32 (31%) occurred in women. In comparing individual factors (age, height, weight, etc) exposure factors (type and symptoms of DCS, recurrences, symptom onset, etc) between the men and women treated, a few significant difference, besides sex itself, were found. These findings will be presented.

A 26 year old woman diver, active in sports and in excellent physical condition, made a dive to 70 feet for about 5 minutes, then to about 50 feet for 29 minutes. Water temperature was 82°F, the diver wore a flight suit for protection and was diving with a very experienced buddy. Upon surfacing, the Repetitive Group for a 70 foot/34 minute schedule was assigned, ie. Group G. One hour 38 minutes were spent on the beach drinking coffee and relaxing prior to making a second dive to 45 feet for 43 minutes. Both dives were without incident except that the woman felt much colder than on any of her previous ten logged dives, in fact the second dive was terminated due to chilling.

Upon exiting the second dive, she experience severe back pains but felt the pains were normal in that her menstrual period was due to start in two days. However, she noted that the back pains were worse than normal. Following the dive she put away her gear and upon arrival home went to bed due to the persisting and worsening back pains. No medication was taken and the general discomfort and back pains grew in intensity. By six hours post dive her worsening condition was the onset of pain in the knee joints caused her to seek medical help. She was placed in oxygen at the medical facility and transported to a nearby US Navy recompression facility.

The diver was taken to 60 feet on US Navy Treatment Table 5, with almost immediate relief in most joints. During the course of treatment her back pain recurred so treatment was completed on Treatment Table 6. One hour after completing Table 6 the woman started having tingling sensations so was re-treated in the chamber. Apparently, there were some residual deficits noted following the second treatment which resolved over a period of a few days. She was subsequently recertified medically for diving and has continued her diving without untoward reaction.

Possible contributing factors in this case include the fact that the night before the dives she took two birth control pills at 11 pm having missed taking one the day before, and the fact that the diver is a heavy smoker. She had smoked half a pack of cigarettes between the time she got up and her first dive on the day of the reaction. She had also smoked about 9 cigarettes during the surface interval between dives.<sup>1</sup>

If the classical publications on the subject of decompression sickness are read, one will find that the subject of sex as a factor in determining susceptibility of decompression sickness (DCS) is dealt with in three words - "no data available".<sup>2,3</sup> With respect to diving, especially in sport diving, this is still the case and will in all likelihood remain so - "no data available"!

Yet there are anatomical and physiological differences between the sexes that can be hypothesized to result in an increased susceptibility to DCS among women. The factors, which might be expected to increase the risk of DCS in women, include a greater proportion and different distribution of body fat, fluid shifts and fluid retention (oedema) as related to the menstrual cycle, cyclic hormonal changes, and use of oral contraceptives. Other questions with respect to any hypothetically greater susceptibility to DCS in women that need answers include:

1. Are there perfusion anomalies found in women or more prevalent in women that could be related to an increased probability of bubble formation?
2. Are there haematological differences, which are more prevalent in women, that could be related to platelet aggregation triggered by bubbles?
3. Are vasospastic phenomena or release of vasoactive substances, as may be caused by bubbles, more likely to be found in some or all women?

While little or no laboratory research has been conducted in the area of differences in DCS between the sexes, there is data available now that does indicate a greater susceptibility among women. This data was gathered on women exposed to high altitudes in the US Air Force's altitude chamber indoctrination program.<sup>4</sup> In most respects altitude DCS is the same as DCS encountered in diving. There are some differences which may make the extrapolation to diving somewhat confusion, but when individual case histories are compared there are also many

similarities. During the 12 year period from 1966 through 1977 there were 104 individuals treated by recompression for altitude DCS, 32 (31%) of whom were women. More detailed records were available at the USAF School of Aerospace Medicine where 22 of the 32 DCS cases in women occurred. This allowed for a determination of the incidence (ie. # of cases/# of exposures) if DCS for both men and women exposed to altitude for the 10 year period from 1968 through 1977. The incidence in men was 0.09% while in women it was 0.36%, and this four fold greater incidence is statistically significant to P 0.0005.

In comparing, among all 104 USAF-wide cases, individual factors (age, height, weight, etc), exposure factors (type of exposure, exposure time, prior exposures, etc) and case data (type and symptoms of DCS, recurrences, symptom onset, etc) between the men and women treated for altitude DCS a few significant differences, besides sex itself, were found. Within the category of individual factors the women were significantly different from the men in height, weight and body build - certainly not an original observation! However, size and slender build are generally associated with a reduced risk of DCS, not an increased susceptibility as found in this data. There was also statistical significance in the larger number of women who reported a history of vascular or migraine headaches and previous altitude reactions. In the category of exposure factors, women with DCS had attained a lower maximum exposure altitude than the men, but this data is biased by the fact that since 1973 women have generally been exposed to lower altitude profiles in the altitude chamber. Nevertheless, this finding would support the finding of a greater susceptibility to DCS. Regarding case data, significantly more women had the onset of bends pain at altitude than men and more women had cutaneous (skin) manifestations than men. Finally, while the numbers are too small to test statistically, 7 (22%) of the women treated had recurrences of manifestations either during or following recompression therapy and required retreatment in the chamber. This only occurred in 2 men (3%). An the only cases which resulted in lasting neurological deficits, in spite of prompt and adequate therapy, occurred in two women.

The conclusions from the data can be summarized as follows. In spite of their smaller mean size and stature, women are four times more susceptible to altitude DCS, have more skin symptoms, have a more rapid onset of bends pain, have more recurrences and lasting effects of DCS when compared to men exposed to the same altitudes in an identical manner. Interestingly, many of these findings are seen in the case history cited at the beginning of this paper. It is tempting, therefore, to hypothesize that the same differences documented in terms of altitude DCS may well be found in diving women.

Prescription Dive conservatively with respect to the decompression limits. Always stay well within the no decompression limits on single and repetitive dives. How much conservatism is enough? There can be no definite answer to this question until studies are, if ever, performed. As a reasonable set of recommendations, reduce the no decompression limits for dives to 90 feet or more by 5 minutes, by 10 minutes for dives shallower than 90 feet, and use total dive time (surface-to-surface time) for the maximum depth of the dive to attain the repetitive group designation.

How about the "Pill" and susceptibility? There are many reasons why oral contraceptives may increase susceptibility to DCS - but there is no evidence because studies have not been done. In the meantime, only the same prescription can be given, DIVE CONSERVATIVELY! As an alternative there may be other birth control methods which a woman diver would find acceptable and which would be less likely to have any effect related to DCS susceptibility or severity. A

relatively new method of birth control that appears effective and convenient is the Progestasert System.<sup>5</sup> This interuterine device differs from the "normal" IUD in that it is a hormonal regulator like the Pill, but the hormone acts directly on the uterus and not via the circulation. Therefore, it would not be expected to have any synergistic effect on women divers. Jo Ann Wesner, a diving instructor in Illinois kindly provided this author with the information on the Progestasert System and is attempting to gather data on its use by divers. I encourage all of you interested in this system or who are using it to contact Jo Ann directly.

#### Thermal Balance in Women Divers

As previously stated, women have a higher proportion (and more interesting distribution) of body fat compared to men. This layer of subcutaneous fat should and does serve as a good insulator due to the lower thermal conductivity of fat. Why then is it a common observation among divers that many women suffer the effects of diving in cold water sooner than their male counterparts?

In a 1974 study on the metabolic and thermal responses of women during cooling in water it was found that an individual's sensitivity to cold was based on two factors: 1. the percentage of body fat, and 2. the ratio of surface to body mass.<sup>6</sup> It was observed that lean women who had less than 27 percent body fat had a large ratio of surface area to body mass, and this resulted in cooling at a faster rate. Above 30 per cent body fat, men and women were equal in their sensitivity to cooling and maintained similar low levels of heat production in cool water.

On the other end of the scale, a woman is also likely to suffer from over heating sooner than the male, since sweating in women does not begin until their body temperature rise is 2° to 3° higher than males. In addition, the woman has a lesser number of functioning sweat glands to aid in evaporative heat loss.<sup>7</sup>

Prescription Anyone, man or woman, who cools easily should use appropriate thermal protection in the form of a properly fitting wet or dry suit. Don't base your requirement for thermal comfort when diving on what your buddy or other divers use in the same water - if you need a uni-suit to remain comfortable in Cayman waters while everyone else is in a bikini, wear it - it's your body!

During rather lengthy periods of carrying heavy equipment, suiting up or otherwise getting overheated during the hot summer months, the woman diver should periodically cool off by an occasional dunking in the water if at all possible. Starting a dive in an overheated condition is not only miserable, it is also unsafe.

#### Diving During Menstruation

The general advice given to women regarding physical activity during the menstrual period is "if you feel well, do it". This seems to be valid since the menstrual period did not prevent women from winning medals in the Olympics of 1972 and 1976. On the other hand, if the woman experiences severe cramps or discomfort, it is unwise to engage in strenuous physical activity.

Knowledge concerning the state of the menstrual cycle and susceptibility to decompression sickness, narcosis or any other diving related problem is general lacking. However, there are some working hypotheses that may make the advice that "if you feel well, do it" not necessarily sound with respect to diving. For example, fluid retention and edema preceding and during the menstrual period

may impair blood flow and inert gas elimination, giving an increased likelihood of bubble formation and decompression sickness.

What is the danger of shark attack for a menstruating women diver? The cyclic shedding of the lining of the uterus, under hormonal control, results in a loss of approximately 50 to 150 cubic centimetres of blood and cellular debris over the average of three to five days.

Prescription Regarding diving during or just prior to menstrual period, the only advice is that previously given, ie. dive conservatively. Stay well within the no decompression limits.

Regarding sharks, the small quantity of blood lost during any given dive, the use of internally worn tampons, and the lack of any evidence of shark interest in a menstruating diver leads to the conclusion that the woman should forget about sharks and enjoy her dive.<sup>8</sup>

#### Diving While Pregnant

As previously indicated, there is a lack of data regarding women divers, specifically pregnant divers. However, it is known now that dives made near the limits of the no-decompression tables can produce intravascular bubbling in many subjects, even without the development of symptoms. What is not known is whether such bubbles will form in the developing fetus on such dives. One study conducted in dogs indicated that the feti were resistant to bubble formation even when the mother displayed marked bubbling following decompression and even though the amniotic fluid surrounding the feti contained numerous large bubbles.<sup>9</sup> A more recent study in sheep produced the opposite results, ie. more bubbles in the fetus than in the mother.<sup>10</sup> While human observations may never be performed, the consequences of any bubble formation in the developing fetus could prove to be disastrous.

Another consideration is the possible effect of elevated oxygen partial pressures on the unborn children of pregnant divers. While breathing air at depths of 30 feet or less does not raise the partial pressure of oxygen to levels that might be predicted to cause difficulties, breathing air at 124 feet produces an oxygen pressure equal to breathing 100 per cent oxygen at sea level. Pressures of oxygen this high are known to produce retinal damage, resulting in blindness, in premature infants. Therefore, the unborn child might be expected to be very sensitive to elevated oxygen pressures that could be encountered in scuba diving. Again no direct studies have been conducted.

Other factors in pregnancy may present difficulties to the diver, ie. nausea, fatigue, backaches, clumsiness and poorly fitting equipment. Hormonal and physiological changes, including fluid retention and increased fat stores, may increase the risk of decompression sickness in the pregnant diver.<sup>8</sup>

Around the fourth month of pregnancy there is usually increased swelling and sensitivity of the mucous membranes which may give rise to difficulties with equalizing middle ear and sinus pressures.<sup>8</sup>

One last consideration concerns the possible effects of treatment of a pregnant diver with decompression sickness. Present treatment schedules call for the use of 100 per cent oxygen at 60 feet equivalent depth in the recompression chamber. This raises the arterial oxygen pressure from a normal 100mm Hg to over 2000mm Hg. This high an oxygen pressure would almost undoubtedly have disastrous effect on the vulnerable fetus, yet the only recourse would be to treat the stricken mother.

Prescription The Undersea Medical Society guidelines for scuba diving while pregnant are protectively conservative, ie. NO SCUBA diving deeper than 30 feet, and avoidance of decompression diving. The second recommendation, of course, should apply to all sport divers.

After delivery it is generally recommended that the new mother avoid diving for six weeks to preclude the possibility of uterine infection.

REFERENCES:

1. The interesting case report cited was kindly provided by NAUI Instructor, Lt. Col. James L. Baynes, Wing Diving Safety Officer, Anderson AFB, Guam.
2. Fulton , J.F. (ed), Decompression Sickness, W.B. Saunders Co., Philadelphia, 1951.
- 3 Fryer , D.I., Subatmospheric Decompression Sickness in Man, Circa Publications, Inc., New York, 1969.
- 4 Bassett, B.E., "Decompression Sickness in Female Students Exposed to Altitude During Physiological Training", preprints of the Annual Scientific Meeting of the Aerospace Medical Association, pp 241-242, 1973
- 5 Information provided by Jo Ann Wesner, 400 Glen Farm Lane, Lake Zurich, Illinois 60047.
- 6 Kollins, J., et. al., "Metabolic Responses of Women During Cooling in Water", J. Appl. Physiol. 136: 577-580, 1974.
- 7 Harris, D.V., "Women in Sports: Some Misconceptions", J.Sports Med., March/April, 1973: 15-17
- 8 Bangasser, Susan, "Physiological Concerns of Women Scuba Divers", Proceedings of the Ninth International Conference on Underwater Education, NAUI, 1977
- 9 McIver, R.G., "Bends resistance in the Fetus", preprints of the Annual Scientific Meeting of the Aerospace Medical Association, p31, 1968.
- 10 Fife, W.P., Simmang, C. and Kitman, J.V. "Preliminary Study on Susceptibility of the Fetal Sheep to Acute Decompression Sickness", In Press

Public Health an N.S.W. initiative

Human "guinea pigs" will eat oyster to see if they are safe, the NSW Parliament was told yesterday. The Conservation and Water Resources Minister, Mr Lin Gordon, said the panel of volunteers would eat oysters to find out if they contained a harmful virus. He said the test was part of a research program set up by the Fisheries Department and the Health Commission and costing \$120,000. When a grower felt his oysters were ready for sale to the public, the would be tested by the Health Department to see if the bacteria count was at an acceptable level. "Further to that, there will be testing panels which will test to see if any virus is present in the oysters. This can only be done by a panel of volunteers, who will eat the oysters. Of course it's a kind of Russian roulette." Four or five months ago more than 2,000 cases of gastroenteritis were reported after people had eaten oysters. "This was said by the Health Commission to be the largest outbreak of food poisoning ever to happen in Australia, and possibly the world" he said. (Daily Telegraph 16 Nov 78)