Comparative Data from 2250 Male and Female Sports Divers: Diving Patterns and Decompression Sickness

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St. Leger Dowse M, Bryson P, Gunby A, Fife W. *Comparative data from 2250 male and female sports divers: diving patterns and decompression sickness.* **Aviat Space Environ Med 2002; 73:743–9.**

Background: The aim of the study was to compare the diving habits and histories of men and women in recreational scuba diving. ***Methods:*** More than 10,000 questionnaires were circulated to recreational divers in the United Kingdom. Retrospective, broad-based information was requested concerning general health, smoking, alcohol, recreational drug use, diving habits and histories, and physician-confirmed and self-diagnosed episodes of decompression sickness (DCS). Data relating only to women were also gathered. Questionnaires were anonymous. ***Results:*** Over four years, 2250 divers responded, 47% of whom were women. Of the 458,827 dives reported, 31% were by women. Differences in diving habits were observed between men and women, which included number of dives per annum, maximum depths dived, and dives with extra stops. When the level of experience was taken into account in this study group, the estimated rate of DCS in men was 2.60 times greater than for women. ***Conclusions:*** In this study, comparison between men and women in recreational diving differed from the initial evaluation when underlying factors were taken into account. Future studies should attempt to control for underlying factors in the data gathering and data analysis.

Keywords: gender, scuba diving, female, decompression sickness, menstruation.

THERE HAVE BEEN FEW broad-based studies to evaluate potential differences between men and women in recreational scuba diving (1,9). Some studies have suggested that women may be more susceptible to DCS than men (1,2,3,21), while other studies have found no gender difference (5,6,7,9,20,23). Results, therefore, are conflicting and controversial (17). One possible source of confusion is that past studies have not taken into account gender differences in diving habits (1). Studies have also suggested that there may be a relationship between the incidence of DCS and the phase in the menstrual cycle (3,5,12,18), with some studies also intimating a relationship between the oral contraceptive pill and DCS (1,4,19). To date there has been no organized attempt to collect data with regard to the menstrual cycle and the diving habits of women. With controversy surrounding these issues, a workshop sponsored by the Undersea and Hyperbaric Medical Society (UHMS) in 1986 suggested the need for further data collection (8).

This study was initiated to gather retrospective data pertaining to any differences in diving habits and histories between the genders, to explore the effects of those differences on the incidence of DCS, and to compile an information resource which might assist in the future development of prospective data collection.

METHODS

Between 1990 and 1994, the Diving Diseases Research Center (DDRC) distributed 10,560 eight-page, anonymous questionnaires to recreational divers in the United Kingdom via dive clubs, lecture tours, dive shows, and medical referees (diving medicine physicians). The information requested was broad-based and retrospective, pertaining to general health, smoking, alcohol, recreational drug use, and diving habits and histories. The respondents indicated whether the dives were logged or estimated. Women were asked menstrual history detail, contraceptive methods, and if they had dived while pregnant. Data from physician-diagnosed and self-diagnosed incidents of DCS were also gathered. Signs and symptoms of DCS were classified into five categories (fatigue, rashes/itches, pain only, tingling/numbness, weakness/paralysis). Diving practices at the time of the incident were also requested. Free-form response was encouraged where replies were not suited to fixed-option responses. No incentive was offered to encourage response to the project. Divers were asked to report on diving experience in blocks of up to 5 yr. Data from the questionnaires were transferred to a DataFlex database (developed specifically for this purpose) by two trained data entry technicians. Quality assessment was conducted, with the principal investigator scrutinizing 100% of all the maximal depths entered, the records of DCS incidents (both physician-confirmed and self-diagnosed), and dives during pregnancy, and where other health comments were received. Random checks were conducted of the re-

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This manuscript was received for review in May 2001. It was revised in November 2001. It was accepted for publication in April 2002.

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maining records. Every effort was made to ensure the integrity of the data, given the limitations regarding anonymous, retrospective data collection.

Statistical analyses were performed by one of the authors who is a professional statistician. Initial analyses of gender differences were performed using χ^2, Fisher's exact tests, and z-tests as appropriate. Analysis of possible interactions of gender and other diving history variables utilized logistic regression. The rates of DCS episodes per 1,000 dives were analyzed using a log-linear regression model taking into account underlying factors (years of experience and age). Additionally, when addressing the differences in maximal depth dived, a log-linear model also took into account the years of experience of the divers. Results were designated significant for $p < 0.01$, and highly significant for $p < 0.001$. When dealing with weights of the respondents the following body mass index (BMI) calculation was used: weight in kilograms divided by height in centimeters squared. A unit of alcohol was defined as half a pint of beer, lager, or cider; one measure of spirits, sherry, or vermouth; or one glass of wine.

RESULTS

Completed questionnaires were received from 2250 divers (53% male, 47% female). The age range was 14 to 81 yr. Overall, the age group from 31 to 40 yr contained the highest number of divers. The ratio of men to women varied over the age groups (**Fig. 1**) with more women in the younger age groups. This difference in age distribution is highly significant.

Diving Differences

Diving experience across both genders ranged from less than 2 yr to more than 26 yr experience. There was a highly significant difference in the distribution of years of diving experience between men and women, with women reporting fewer years of experience (**Fig. 2**), and corresponding with the age distribution by gender (Fig. 1).

A total of 458,827 dives was reported (**Table I**), with

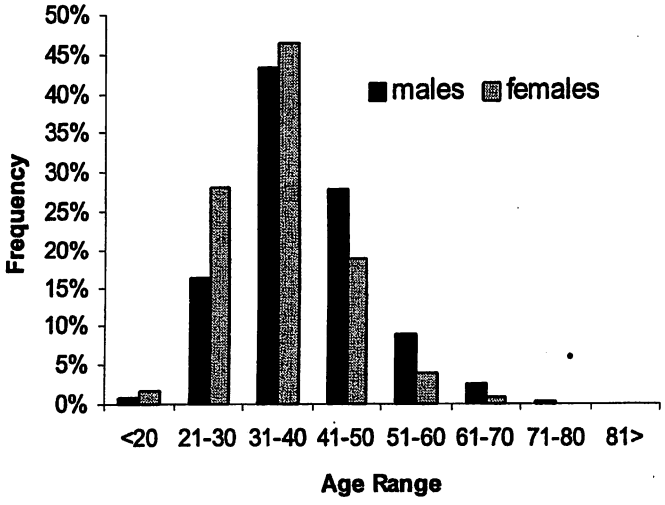

Fig. 1.

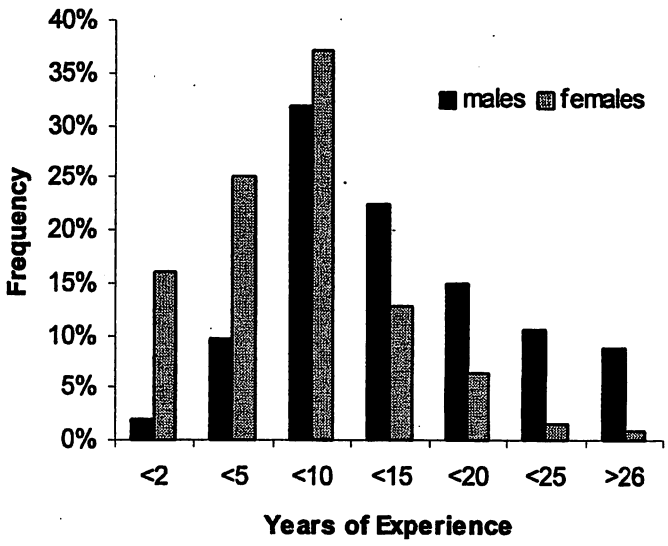

Fig. 2.

31% by women. Of the 20% of respondents who did not log all their dives, the majority (69%) were men. Overall, women averaged significantly fewer dives per year than men (Tables I and II). Significantly fewer women than men reported dives requiring mandatory decompression stops (**Table II**). Additionally, the proportion of decompression stop dives differed significantly, with women reporting less decompression dives (Tables I and II). In order to determine if this difference was caused by less experience among women, we examined the proportions of divers reporting decompression dives against years of experience and gender. There was a highly significant correlation between gender and proportion of divers reporting decompression dives and between experience and proportion. Therefore, even allowing for experience, less women than men performed decompression dives.

Initial examination suggested that there was a highly significant gender-related difference in the maximal depths dived (**Table II**). As with the decompression dives, the maximal depths were examined by years of experience to ascertain if the difference in maximal depths between genders would persist. Both experience and maximal depths were highly significant effects, but gender did not produce a significant effect. Therefore, there was no gender-related difference in the depths dived when underlying factors had been taken into account.

We evaluated differences in risk-taking behavior by investigating not only the maximal depths dived and

TABLE I. NUMBER OF DIVES REPORTED BY MALES AND FEMALES.

Gender	*Dives With Stops	Dives Without Stops	Total Dives
Male	34,950 (11.00%)	282,894 (89.00%)	317,844 (100%)
Female	10,751 (7.63%)	130,232 (92.37%)	140,983 (100%)
Total dives	45,701 (9.96%)	413,126 (90.04%)	458,827 (100%)

* Dives requiring a decompression stop as defined by tables and computers.

TABLE II. SUMMARY OF GENDER RELATED DIFFERENCES IN DIVING WHEN OTHER FACTORS WERE TAKEN INTO ACCOUNT.

	p-Value or Rate Before Corrected for Underlying Factors	p-Value or Rate After Corrected for Underlying Factors	Males	Females
Total number of dives			317,844	140,983
Mean number of dives per year			56	37
Respondents reporting decompression stop dives	<0.0001	<0.0005	77.08%	63.53%
Proportion of decompression stop dives	0.0000		11%	7.63%
*Average max depths dived	<0.0001	>0.10	40–49m	30–39m
Number of days with more than one dive in the day per diver	<0.0001	>0.1	73	41
Extra stops not required by tables or computers	0.04	<0.005	50.17%	47.71%
Confirmed DCS rates per 1,000 dives	1.67 fold greater rate in females	2.57 fold greater rate in males	0.157	0.262

* Average reported is the median depth range. Note that the analysis compared males with females by depth range using a log-linear model.

the percentage of decompression stop dives, but also the number of dives per day and the practice of adding extra stops where not required by decompression schedules. There was no difference in the proportions of men and women reporting more than one dive per day. Divers were asked if they routinely added extra stops in addition to those demanded by the tables, taking into account the different recommendations by the training organizations. Of the respondents, 49% made extra stops regularly, whereas 51% did not. Initially there was no significant difference between men and women in this group. However, when the divers who routinely added extra stops were further categorized by years of experience, there was a highly significant difference between genders, with fewer women making extra stops than men with the same level of experience.

General Health Differences

In the study population, a total of 28.04% of the divers reported they smoked cigarettes during their diving careers (33.50% of the men and 21.81% of the women). This compares with the British Central Government Statistics Office 1990 data wherein 31% of men and 30% of women over the age of 16 yr smoked (14). Of the respondents, 20 (16 men, 4 women) smoked 40 or more cigarettes a day, and 3 (2 men, 1 woman) admitted to smoking 50 and 60 cigarettes a day.

More than half of the divers (57%) admitted they had consumed alcohol within 12 h before diving. Of these, 63.8% were men. Thus, highly significantly more men than women admitted to consuming alcohol within 12 h before diving. Thirty-four respondents, all men, consumed 50 units or more on a regular weekly basis.

Nearly 4% of the respondents admitted to the use of prohibited drugs at some time during their diving careers and these ranged from derivatives of the Cannabis Sativa plant to cocaine, LSD, and amphetamines. We could not establish if prohibited drugs were a contributory factor in any of the DCS incidents.

Differences in weight status (BMI) between men and women were highly significant, with comparison of divers' BMIs with the national average rates (11) also giving highly significant results for both men and women. Among the divers surveyed there were more "normal" and fewer "overweight" and "obese" women (**Table III**), while among men, although there were more "normal" weight individuals, there were also more "overweight" men than in the national population. This is likely to be caused in part by the distribution of ages among the survey population (more young women than men).

Data Specific to Women

Of the female respondents, 49 were not menstruating, and reported a previous hysterectomy or were menopausal. The remaining 1,001 female respondents were asked to record whether in their opinion they "regularly," "sometimes," or "never" suffered from excessive fluid retention, premenstrual tension, sudden temperature drop, or perceived impaired reactions and/or accidents. These observations specific to women were of a general nature and applied whether or not the respondent dived while menstruating, relying on how the respondent perceived she was affected.

Of the women, 93% continued to dive while menstruating. Of the 7% who refrained from diving while menstruating, 35% reported that they regularly or sometimes suffered from perceived impaired reactions and/or accidents. In comparison, of the 93% of women who continued to dive during menses, 33% complained they regularly or sometimes suffered perceived impaired reactions and/or accidents. The perceived impaired reactions were reported as feelings of panic and anxiety, lack of coordination, and an inability to react in

TABLE III. WEIGHT STATUS AS DEFINED BY BODY MASS INDEX.

Gender	Under	Normal	Over	Obese	Totals
Males	30 (2.51%)	559 (46.78%)	522 (43.68%)	84 (7.03%)	1195 (100%)
Females	98 (9.37%)	755 (72.18%)	169 (16.16%)	24 (2.29%)	1046 (100%)
Totals	128 (5.71%)	1,314 (58.63%)	691 (30.84%)	108 (4.82%)	2241 (100%)

a given situation. Additionally, 12% of this group reported their dive profiles were more conservative during menses.

Decompression Illness

All respondents (male and female) were asked if, in their opinion, they had suffered a DCS episode and if the incident had been confirmed by a physician. Respondents were also asked to record if the incident was treated in a recompression chamber; the clinical diagnosis, signs, and symptoms; maximum depth of the dive; and a range of questions pertaining to any other factors during the dive in question. Of the total respondents, 6% (86 men and 49 women) reported 159 "incidents" of DCS, with 87 confirmed by a physician and 72 self-diagnosed cases (**Table IV**). In some instances the untreated confirmed cases of DCS were referred to a hospital, but not treated with recompression. It is unclear why some physician-confirmed cases of DCS were not treated, and due to the anonymity of the questionnaires it was not possible to investigate these data further. The proportions of confirmed and self-diagnosed DCS were not significantly different between men and women (Table IV). The distribution of symptoms was significantly different when comparing the physician-diagnosed group as a whole, with those of the self-diagnosed group (**Table V**). The overall proportion of respondents presenting DCS with multiple symptoms was 42.8%, with a significant difference in the proportions of respondents with multiple symptoms between men (39.6%) and women (48.3%).

There is also a significant difference in the proportions of respondents with multiple symptoms between the three groups: confirmed and treated in a chamber (62.0%), confirmed and not treated in a chamber (37.5%), and self-diagnosed and not treated (25.0%). When examined by diagnosis group, the difference between gender in the confirmed and treated in a chamber group is highly significant, where the proportions of multiple-symptom DCS for men is 54.8% and for women 72.4%. No other groups were significant. While women represented 47% of the overall respondents, they only performed 31% of the total dives. Of all the physician-confirmed DCS episodes, 43% were in women. It would be expected that proportionally the women in this study would have a significantly lower ratio of DCS, as our data shows that the women had less aggressive dive profiles than the men (not as many decompression stop dives, Table II). The self-diagnosed group was now excluded, leaving 37 physician-confirmed cases of DCS in women and 50 physician-diagnosed cases in men. The women now had a rate of 0.262 confirmed DCS per 1,000 dives and the men a rate of 0.157, suggesting a 1.67-fold greater rate of DCS in the women (Table II).

Because 28% of the overall dives recorded by the total respondents were "estimated" (rather than from written logs), we examined the data further. When all respondents who had estimated their number of dives within the physician-diagnosed incident cases were excluded, the women had a rate of 0.293 confirmed DCS per 1,000 dives, and the men a rate of 0.119 confirmed DCS per 1,000 dives, resulting in a 2.46-fold greater rate of DCS in women.

We then compared the experience and number of diving years of the total of the physician-diagnosed DCS respondents by gender. Two male respondents did not provide useable information regarding the date of the DCS episode and were excluded. The effects of both gender and experience were highly significant. When analyzed by level of experience, the estimated rate of DCS in men was 2.60 times greater than for women (Table II). The rate of DCS among women is significantly lower in all the different experience groups (**Table VI**). The reason that the overall rates (not taking experience into account) showed the converse of this is due to the preponderance of inexperienced women in the survey population. It is interesting to note that the rate of reported DCS diminishes with increased experience. There is a 9-fold drop in rates between < 2 yr and < 5 yr experience groups, and an almost 5-fold drop in rates between < 5 yr and < 10 yr experience groups. Other metrics of interest with regard to DCS include smoking history and weight. Of the respondents reporting DCS, fewer women smoked than men. Comparing the DCS data with the overall rate within the study, there was no difference in the rates of smokers and non-smokers between divers that reported DCS and those that did not. Weight is considered a factor when contemplating susceptibility to DCS. Our data did not confirm this belief. In terms of BMI, we found no significant difference in the rates of DCS between women and men and between those divers who reported DCS and those that did not. In both women and men the distributions of weights were the same among DCS respondents as among the rest of the survey population.

With regard to data specific to women, owing to lack of accurate record keeping by women regarding their last menstrual period we were unable to supply meaningful data in this area of the survey. We established that 22% of the 58 DCS cases occurred while menstruating. The remaining 78% of the women were not menstruating or could not remember the phase of their menstrual cycle at the time of presentation. Therefore, we could not attempt to establish whether or not there

TABLE IV. DISTRIBUTION OF CONFIRMED AND SELF-DIAGNOSED INCIDENTS OF DCS.

Gender	Confirmed & Treated in a Chamber	Confirmed & Not Treated in a Chamber	Self-Diagnosed & Not Treated	Totals
Males	42 (41.58%)	8 (7.92%)	51 (50.50%)	101 (100%)
Females	29 (50.00%)	8 (13.79%)	21 (36.21%)	58 (100%)
Totals	71 (44.65%)	16 (10.06%)	72 (45.29%)	159 (100%)

TABLE V. NUMBER OF SYMPTOMS REPORTED FROM CONFIRMED & SELF-DIAGNOSED INCIDENTS.

	Confirmed & Treated in a Chamber	Confirmed & Not Treated in a Chamber	Self Diagnosed	Totals
Fatigue	22 (59%)	4 (11%)	11 (30%)	37 (100%)
Rashes/itches	15 (24%)	9 (15%)	37 (61%)	61 (100%)
Pain only	27 (46%)	4 (7%)	28 (47%)	59 (100%)
Tingling numbness	38 (64%)	4 (7%)	17 (29%)	59 (100%)
Weakness paralysis	37 (86%)	3 (7%)	3 (7%)	43 (100%)
Totals	139 (54%)	24 (9%)	96 (37%)	259 (100%)

was a relationship between the menstrual cycle and decompression illness. However, statistically one would expect roughly 25% of incidents in women to occur during menstruation, assuming a 28-d cycle.

There was no statistical difference between those women who suffered DCS and were taking the oral contraceptive pill, and those who were not. Given the overall unreliability of some women (both on and off the oral contraceptive pill) to record their menstrual records at the time of the incident, these data should be regarded only as an interest factor.

DISCUSSION

The study demonstrates that some differences in diving habits and histories exist between the men and women who responded to this survey (Table II). The study also illustrates the difficulties in gathering data of this type and interrogating data that may be affected by reporting bias. It also demonstrates the influences of underlying factors on data analysis and outcome.

Diving Differences

The large number of novice women divers could indicate that more women are joining the sport. Alternatively, it could be that although women appear to be joining at the lower age range (21 to 30 yr), women could be leaving the sport sooner than men. Although our data broadly reflected that of the Divers Alert Network (DAN) Project Dive Exploration (PDE) study, DAN reported a higher number of men than women in the 20–29 age group, but more women in the 10–19 age group (15).

There were significant differences between men and women in the types of diving performed in our study. The maximum depths dived by all respondents were deeper than in the PDE (15), possibly reflecting the type of diving commonly taking place in the UK. In our study men were more likely to perform more dives per year and to perform dives requiring staged decompression stops, even when years of experience were taken into account. It would also appear that women showed greater attention to detail, in that they logged the majority of their dives.

TABLE VI. RELATIONSHIP BETWEEN ESTIMATED RATE OF DCS PER 1,000 DIVES AND YEARS OF EXPERIENCE.

Years of Experience	Males	Females
>26	0.01	0.01
<25	0.05	0.02
<20	0.06	0.02
<15	0.09	0.03
<10	0.24	0.09
<5	1.16	0.45
<2	10.52	4.09

Overall DCS rate across males and females is 0.19 per 1,000 dives.

Across the study population as a whole, decompression stops were taking place at 3 m, 5 m, and 6 m, together with a variety of other empirical combinations used at varying depths according to the dive profile. Some divers only made extra stops if dives exceeded a certain depth, but this varied from dives "over 10 m" to dives over 25, 30, 36, and 40 m. This demonstrates the different manner in which the term "deep" is perceived. Quite complicated "do it yourself" versions of the tables were quoted, for example, "on dives longer than 30 min or dives deeper than 25 m and where 50% of the dive was deeper than 15 m, then 2 min were added at 6 m." Some divers admitted to staying in the water until they had used up their air. These extra stops were made at any depth between 6 m, 5 m, and 3 m or "hanging around in shallow water." Another respondent "only made stops on saturation dives." He defined a week's diving holiday as saturation diving. These comments illustrate some of the challenges in interpreting survey data.

General Health Differences

The study population broadly reflected the non-diving population health trends at the time of the study. A highly significantly fewer number of women divers smoked when compared with the government statistics, whereas for men there was no statistical difference in comparison with the general population. Data from the Office for National Statistics 1996–7 report that 28% of the UK population over 16 yr of age smoked cigarettes (10). Although 57% of the respondents reported that they had consumed alcohol 12 h prior to diving, we were not able to determine from the data available to us the number of units consumed prior to diving. There were significantly more men than women.

There may be cause for concern when considering the underlying medical conditions with which some divers were apparently diving. Two respondents (1 man and 1 woman) reported suffering from epilepsy; both were diving while taking anti-convulsant drugs. The man reported two confirmed DCS episodes.

The use of recreational drugs in conjunction with diving by nearly 4% of respondents is worrisome. Some free-format response indicated the use of recreational

drugs the night before diving. Perhaps training organizations should include information regarding residual times and the potentially negative effects of drugs on judgement.

The way in which women perceived the effect of diving on the menstrual cycle and their interpretation of menstrual symptoms varied from one respondent to the other. From the 109 women who reported their dive profiles were more conservative during menstruation, free format responses included diving to shallower depths, avoiding long dives, making extra stops, and shortening the bottom time. These changes in diving habits may affect the interpretation of data with regard to the effect of menstruation on DCS rates. Many women also commented on the perceived effect of menstruation on other dive-related issues including: tending to feel more tired, feeling colder, being nervous, having slower reactions, perceiving panic, sensing physical weakness, or being more susceptible to narcosis.

Because we do not know if there is a relationship between the menstrual cycle and DCS, it could be argued it is important to encourage women to keep accurate records of the date of their last menstrual period.

Decompression Sickness

Although the self-diagnosed data were not used in our detailed analysis, even allowing for a proportion of wrong self-diagnoses, these data suggest that not all of the DCS episodes within the recreational diving community present to recompression chambers. From the symptom distribution (Table V) it is only reasonable to assume that there would be more mild symptoms in the self-diagnosed category, whereas the physician-diagnosed group would be more likely to contain the higher distribution of serious symptoms, as evidenced by these data. In defense of considering the usefulness of the self-diagnosed data, it could be reasoned that most divers are primarily in the first instance self-diagnosed, given the diver or his buddy makes the decision to refer for treatment directly to a recompression chamber or through the emergency services. We do not know how many of the self-diagnosed cases (if any) would have been diagnosed and treated in a recompression chamber (had they presented), and this could be another confounding factor which may alter the rate of DCS.

These data therefore could challenge previous estimates of the rates of DCS within the recreational diving population (16,22). Further, our detailed analysis of the relationship between DCS and years of diving experience demonstrate the caution one should exercise when attempting to compare men with women in the recreational diving environment without information on confounding variables (Table II).

Clearly, conclusions regarding DCS susceptibility cannot be substantiated from survey data of this type. We only can estimate rates per thousand dives and analyze the different underlying factors between the two genders. Future comparative studies should take these factors into account. These data suggest that willingness to report signs and symptoms of DCS differed between men and women. Women in the study were more likely than men to receive oxygen at the site of the incident, indicating that women may be more inclined to admit to a problem. We did not find any significant difference with regard to smoking, alcohol, or weight between those divers who suffered DCS and those who did not.

CONCLUSIONS

How the activity of scuba diving relates to the differences between the genders has been the subject of much debate over the years, and there are numerous studies on the subject that are unpublished, or published in abstract form only. The controversy and discussion are ongoing. A formal prospective controlled study addressing the issues raised in this paper would result in a long-term and costly commitment for both the investigators and the trialists. Questionnaire studies if carefully and honestly analyzed, though limited, can be utilized as a useful information resource and stimulate debate regarding methods of analysis and findings.

With the diverse interpretations of "safety stops" and depths considered "deep," our data demonstrated that perhaps the training organizations within the recreational diving industry should consider the standards of training given by their representatives. Similarly, the large number of self-reported DCS episodes in this study does raise the question: are divers sufficiently well informed in understanding and recognizing the signs and symptoms of DCS? Is enough time allocated during training in ensuring divers fully understand the possible consequences of the failure to obtain advice and treatment when DCS is suspected?

The study also revealed that when a woman presents at a chamber with suspected DCS, a series of questions pertaining to the menstrual cycle would greatly assist in assessing this area adequately.

The authors acknowledge a response bias may exist in the findings. Divers leaving the sport after DCS are not included in this study, neither are fatalities. Divers suffering adverse events, such as DCS, may be more likely to respond. These data were also from the most active period of the respondents' diving careers.

A study is currently under way to encourage gathering of data relating to the phase of the menstrual cycle and DCS (13). In addition, the DDRC is engaged in a prospective study on diving and the menstrual cycle utilizing "diaries" from a large number of women.

ACKNOWLEDGMENTS

The authors wish to acknowledge the financial generosity of the British Sub Aqua Club Jubilee Trust, Dive Master, and BSAC Exe Dive (1049). In addition, we would also like to extend our deep appreciation for the help and advice received from Richard Moncad, Dr. Peter Densham, Dr. Lyn Creswell, David Waters RN, Dr. Liz Hodges, and Dr. Caroline Fife.

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