A RELATIONSHIP BETWEEN THE MENSTRUAL CYCLE AND DECOMPRESSION ILLNESS: IS THE EVIDENCE BUILDING?

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INTRODUCTION:

Women now have greater involvement within the hypo and hyperbaric work place, as diving instructors, in the military, and as pressure chamber tenders[1,2]. Since the 1970s controversy has persisted regarding the issue of a relationship between the menstrual cycle and decompression illness (DCI - encompasses the two conditions decompression sickness (DCS) and arterial gas embolism (AGE) following pulmonary barotrauma).

Although there are numerous non-diving studies comparing the effect of the menstrual cycle and sporting performance, the number of studies investigating DCI and the menstrual cycle is small. However, both retrospective and prospective work from the hypo and hyperbaric environments suggest a differing risk factor of DCI or problems during diving over a typical 28-day cycle. We scrutinised the available relevant published data ("*The Literature*"). Additionally we reviewed records from women treated with DCI to further investigate any potential relationship ("*The Study*").

METHODS:

The Literature
Results of relevant published studies in hypo and hyperbaric environments from 1988 to 2006 were evaluated.

The Study
Records were evaluated from treatment chambers world-wide where women had been diagnosed and treated in a chamber for DCI (QinetiQ and DDRC 1997 – 2005).

- The study was questionnaire based. Only records fulfilling the inclusion criteria were used where the number of days between the first day of the last menstrual cycle and the problem dive was known.
- Information regarding oral contraceptive pill use, usual length of menstrual cycle, age, depth of dive prior to onset of symptoms, type of symptoms, and smoking habits were also gathered.
- All menstrual cycles were normalised to 28 days (0-27), with day 0 being the first day of bleed. The days from the first day of the last menstrual period (LMP) to the day of the incident were calculated. The Chi-square goodness-of-fit test was used to assess whether the distribution of DCI incidents was uniform across the normalised four weeks (28 days) of the menstrual cycle.

RESULTS:

The Literature
The 7 altitude and diving related publications (abstracts and papers) showed a relationship between DCI, or problems during diving, and the point in the menstrual cycle at which they occur (Table 1).

Dixon (1988) and Dunford (1992) did not specifically account for OCP use in their analyses.

Rudge (1990) and Krause (1998) did not make any conclusions with regard to a correlation between OCP use and DCI.

Lee (2003), Webb (2003), and St Leger Dowse (2006) differed regarding the effect of the OCP and DCI, or between non-OCP and OCP users.

- Lee found no correlation between OCP use and DCI, though when age was taken into account there was a significant difference between OCP and non-OCP use.
- Webb found the data from female exposures from the subjects using the OCP showed a greater susceptibility to DCS in the last two weeks of the cycle.
- St Leger Dowse found no correlation between OCP use and problems during diving from the normalised cycle data, but when data was analysed from menstrual cycles of 28 days only the relationship with problems during diving and OCP usage was significant.

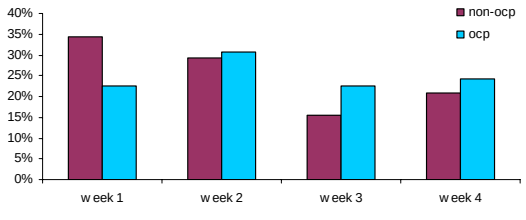
Table 1.

The Literature	Conclusion
Dixon GA, Krutz RW, Fischer MS. Decompression Sickness and Bubble Formation in Females Exposed to a Simulated 7.8 PSIA Suit Environment. *Aviat Space Environ Med* 1988;59:1146-1149.	All 5/30 female subjects with hypobaric DCS were in menses or early phase of cycle.
Rudge FW. Relationship of Menstrual History to Altitude Chamber Decompression Sickness. *Aviat Space Environ Med.* 1990 Jul;61(7):657-659.	Significant inverse linear correlation between number of days since start of LMP and DCS incident, highest risk at the beginning of a 28 day cycle. 81 retrospective records studied
Dunford RG, Hampson NB. Gender-Related Risk of Decompression Sickness in Hyperbaric Chamber Inside Attendants: A Case Control Study. *Undersea Biomed Res (Suppl)* 1992;19:(41)37.	Menses was a significant risk factor for inside chamber attendants, but not for divers in open water. This study was based on small numbers, 9 in total.
Krause KM, Pilmanis AA, Webb JT. The Effect of Menstrual Day on Decompression Sickness (DCS) Incidence in Female Research Subjects. *Aviat Space Environ Med* 1998;69(3):199.	Correlation between menstrual day and DCS: greatest probability being on day two of bleed. 62 retrospective DCS records
Lee V, St Leger Dowse M, Edge C, Gunby A, Bryson P. Decompression Sickness in Women: A Possible Relationship with the Menstrual Cycle. *Aviat Space Environ Med.* 2003 74 1177-1182.	Suggested the risk of DCS may be dependent on the phase of the menstrual cycle with greatest risk of DCS, in the non-OCP group, being in the 1st week of a 28 day cycle, the lowest risk being in week 3. 150 prospective records
Webb T, Kannan N, Pilmanis A. Gender Not a Factor for Altitude Decompression Sickness Risk. *Aviat Space Environ Med. 2003 Jan;74(1):2-10*	Data from the non-ocp women agreed with Dunford, Krause, Lee, & Rudge, showing a reduction in susceptibility from week one through week four of the menstrual cycle. 70 women, 269 altitude exposures
St Leger Dowse M, Gunby A, Moncad R, Fife C, Morsman J, Bryson P. Problems Associated with Scuba Diving are not Evenly Distributed Across a Menstrual *Cycle. J Obstet Gynaecol. 2006 Apr;26(3):216-21*	Problems reported during diving were not evenly distributed over a menstrual cycle and suggested a risk factor associated with menses and diving. The highest was risk in week one, with the lowest risk in week three before rising again at the end of a 28 day cycle. 570 women, >50,000 dives, >11,000 menstrual cycles

The Study
250 records (143 non-OCP, 107 OCP) were suitable for analysis from 23 chambers world-wide. The mean cycle length was 28.7 days (29.11 days non-OCP, 28.0 OCP) with a range of 21 to 45 days reported for the non-OCP users, and little variability for OCP users as would be expected. The age range at the time of the incident was 16-51 years, mean 29.2 years (30.9 non-OCP, 26.8 OCP). The mean maximum depth of the dive recorded prior to the incidents was 22.8m. 24% of the women smoked cigarettes.

The incidence of DCI was not evenly distributed over the 4 weeks of the menstrual cycle. For the non-OCP group there was strong evidence (Chi-square) that the distribution was not uniform ($p<.01$) (Figure 1). For the OCP group however there was no evidence against a uniform distribution using the Chi-square test (Figure 1).

Figure 1. The Study
Percentage of women, non-OCP & OCP users, with treated DCI for each week of the menstrual cycle



DISCUSSION:

The Literature
The conclusions of the literature were all consistent in spite of varying exposures, methodologies, analyses, and differing populations. The available evidence from the literature consistently suggests that there is a relationship between the risk of DCI during hyperbaric or hypobaric exposure, or the occurrence of problems during hyperbaric exposure, and the time in the menstrual cycle. Results were significant, particularly in the non-OCP groups. The issue regarding the OCP is inconclusive.

The Study
Overall the incidences of DCI were not evenly distributed over a typical 28 day menstrual cycle. This was particularly marked in the non-OCP group where there was strong evidence to support the confirmation of a relationship with the menstrual cycle and the risk of DCI.

The OCP findings however are less clear. This may be due to a number of factors such as insufficient data for each week of the menstrual cycle, the varying types of OCP used by the women, and their usage of the OCP. Anecdotal evidence suggests women on the OCP extend their menstrual cycles for social reasons, with a recent study observing extended cycles of 21 to 40 days and more[3].

The Study and the Literature
Many studies assume women on the OCP to have a classic 28 day cycle. It could be argued that assuming a 28 day cycle, or normalising the OCP data, may shift the distribution of incidents across the cycle time-frame. Lee (2003) and St Leger Dowse (2006) found no relationship with the OCP when normalising their OCP data, but when OCP data were analysed in the St Leger Dowse study using only true 28 day cycles, the results were significant. Webb (2003) found a relationship in the last two weeks of the cycle in his OCP study group, but it is unclear whether the women in the study all had a classic 28 day cycle. The debate therefore regarding the risk factor between OCP usage and DCI will be ongoing and remain unclear until OCP usage is more accurately recorded in studies.

The literature over a period of 18 years was taken from both hypo and hyperbaric environments, retrospective and prospective data, and from military and civilian disciplines. Analysis over the menstrual cycle differed between studies, with some observing the incidence of DCI by individuals, whilst some aviation studies observed the incidence of DCI by altitude exposures. In spite of these differences a similar trend was seen in all studies: whether this is the result of hormonal fluctuations of the menstrual cycle remains unquantified and is a subject for further investigation.

CONCLUSION:

We suggest evidence is building that a relationship between the menstrual cycle and DCI may exist. The results of the literature evaluated here are supported by analysis of the data of this study.

There may be a potential health and safety issue emerging regarding women, DCI and the menstrual cycle, and thus a case for implementing prospective research where the variables can be controlled.

REFERENCES:

1. *Unpublished data, British Sub Aqua Club [BSAC] and Professional Association of Diving Instructors [PADI]*
2. *Personal communication UK Health and Safety Executive [HSE]*
3. *St Leger Dowse M, Gunby A, Moncad R, Fife C, Bryson P. The Oral Contraceptive Pill and the Assumed 28-Day Cycle. In press*