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

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St Leger Dowse, M. et al.: A relationship between the menstrual cycle and decompression illness: is the evidence building? Europ J Underwater Hyperbaric Med 2006, 7(4): 75-78. Controversy persists regarding any relationship between the menstrual cycle and decompression illness (DCI). Women now have greater involvement within the hypo and hyperbaric work place. Studies suggest a possible difference in risk of DCI, or problems during diving, over a typical 28-day cycle. We scrutinised the relevant published data from hypo and hyperbaric environments between the years 1988 to 2006. We also reviewed 250 records from a continued study involving 23 treatment chambers where women had been diagnosed and treated for DCI and for which the number of days between the first day of the last menstrual cycle and the problem dive was known. The 7 altitude and diving related abstracts and papers showed a relationship with DCI, or problems during diving, and the point in the menstrual cycle. Analysis of the 250 DCI treatment records also showed the incidence of DCI was not evenly distributed over the menstrual cycle, with more cases treated at the beginning and end of the typical 28 day cycle. The available evidence suggests 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.

Decompression illness, women, menstrual cycle, risk

INTRODUCTION

Women now have greater involvement within the hypo and hyperbaric work place, as diving instructors, in the military, and as pressure chamber tenders. Since the 1970s controversy has persisted regarding the issue of a relationship between the menstrual cycle and decompression illness (DCI).

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 (1-7). We scrutinised the available relevant published data ("*The Literature*") and reviewed records from women treated with DCI ("*The Study*") to investigate any potential relationship. In this paper DCI encompasses decompression sickness (DCS) and arterial gas embolism (AGE) following pulmonary barotrauma.

METHODS

The Literature

Results of relevant published studies in hypo and hyperbaric environments from 1988 to 2006 were evaluated (1-8). These studies have all been presented at international scientific meetings and/or published in peer reviewed journals and considered to be reliable studies which are altered pressure environment and menstrual cycle specific.

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 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).

TABLE 1. Summary of the literature and conclusions:

The Literature	Conclusions
Dixon GA, Krutz RW, Fischer MS. (1)	Altitude DCI. All 5/30 female subjects with hypobaric DCS were in menses or early phase of cycle.
Rudge FW. (2)	Altitude DCI. 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. (3)	Gender related risk of DCI. 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. (4)	Altitude DCS. 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. (5)	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. (6)	Altitude DCS gender related risk. 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. (7)	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.

Controversy surrounds the effects of OCP and non-OCP use. Dixon and Dunford did not specifically account for OCP use in their analyses, whilst Rudge and Krause did not make any conclusions with regard to a correlation between OCP use and DCI (1-4). Lee, Webb, and St Leger Dowse differed regarding the relationships between OCP usage and DCI (5-7). 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 (5). Webb found the subjects using the OCP showed a greater susceptibility to DCS in the last two weeks of the cycle (6). However, 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 (7).

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 mean age at the time of incident was 29.2 years (30.9 non-OCP, 26.8 OCP) with a range of16-51 years. 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).

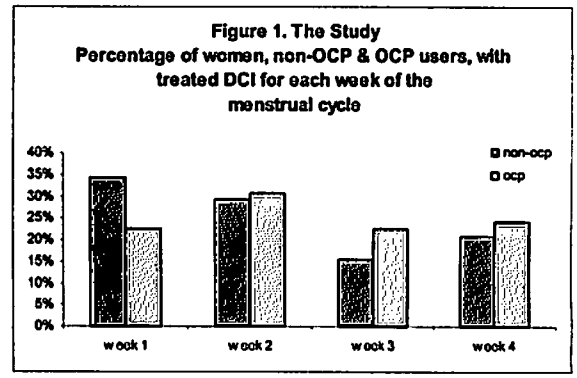

FIGURE 1. Percentage of women, non-OCP and OCP users, with treated DCI for each week of the menstrual cycle

DISCUSSION

The Literature

The conclusions of the literature (Table 1) were all consistent in spite of varying exposures, methodologies, analyses, and differing populations (1-7). 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 time in 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 cycles of 21 to 40 days and more (8).

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 (8). Lee and St Leger Dowse 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 (5,7). Webb 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 (6). 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. The size of the study groups varied widely from 9 to 570 (Table 1). It was also apparent that although some of the retrospective studies were able to initially interrogate records over 11 to 14 years, a large number of records did not fulfil the criteria required to establish any risk that might be associated with DCI and the menstrual cycle (2,3). 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 un-quantified 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.

It is unclear whether these findings from the literature and the study are a result of an increase in risk during the early phase of the menstrual cycle or a protective factor during week 3 of the cycle. 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.

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