Menstruation, Pregnancy, DCI and Diving: 17 Years Focus on Female Divers

Marguerite St Leger Dowse

The Hyperbaric Medical Centre (Diving Diseases Research Centre) DDRC

Studies at DDRC

Men & Women in Diving

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(8):743-749

Scuba Diving & the Menstrual Cycle

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.

Women & Decompression illness

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(11):1177-1182

Pregnancy and Diving

St Leger Dowse M, Gunby A, Moncad R, Fife C, Bryson P. Scuba diving and pregnancy: can we determine safe limits. J Obstet Gynaecol. 2006 Aug;26(6):509-13.

BILL FIFE

- Chief of Aerospace Medical Research Division – School of Aerospace Medicine
- Professor Hyperbaric Medicine Texas A&M University
- Studied effects of survival in space vacuum on astronauts
- Carried out early studies on the effects of diving on pregnancy and the foetus

Men & Women in Diving

M St Leger Dowse, A Gunby, P Bryson, W Fife

- Retrospective dive data
- Comparative - males with females
- Based on a study by Dr William Fife

The men talked about fishing and the women talked about the men.

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Men & Women in Diving

- general health
- smoking, alcohol, prohibited drugs
- diving habits and histories
- decompression illness
- female issues ... menstrual histories
- contraception
- dived pregnancies

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Men & Women in Diving

- 2,250 males & females
- 53% males ... 47% females
- 159 diagnosed & self diagnosed DCI
- 458,827 dives
- Males 56 dives per year
- Females 37 dives per year

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Men & Women in Diving

- 20% of respondents estimated 28% of the total dives in the study
- 77% of the *estimated* dives were from males

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Men & Women in Diving

• number of dives	females did less
• dives with deco. stops	females did less
• divers with >1 dive per day	no difference
• no. of days >1 dive per day	no difference
• maximum depths	no difference
• extra safety stops	females did less

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Men & Women in Diving

- Recreational Drugs
- Derivatives of the *Cannabis sativa* plant
- Cocaine
- LSD
- Amphetamines

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Men & Women in Diving

- Recreational Drugs
- Derivatives of the *Cannabis sativa* plant
- Cocaine
- LSD
- Amphetamines

"Not immediately before a dive. My buddy did and got a bend!"

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Men & Women in Diving

	diagnosed DCI	self diagnosed DCI
males	50%	50%
females	64%	36%
Total DCI	55%	45%

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Men & Women in Diving

rate per 1000 dives

- from *all* dives, estimated & logged
  - males 0.16
  - females 0.26
- from *logged* dives only
  - males 0.12
  - females 0.29

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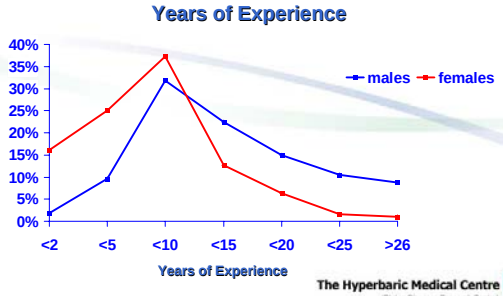
Men & Women in Diving



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Men & Women in Diving

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

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Men & Women in Diving

- factors ... years of experience & number of dives
- males had a *higher* rate than females
- susceptibility V rates?
- overall rate per 1000 dives 0.19

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The menstrual cycle and diving: reported problems during diving (RPDD)

M St Leger Dowse, A Gunby, R Moncad, C Fife, J Morsman, P Bryson

- The aim -
  - Does the menstrual cycle affect some women's ability to dive safely?

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The menstrual cycle and diving: reported problems during diving (RPDD)

- Longitudinal, prospective field study of diary data over an extended period of time, involving recreational female scuba divers

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The menstrual cycle and diving: reported problems during diving (RPDD)

- Information gathered included:
  - General health, social status, gynecological health, oral contraceptive pill (OCP) use
  - All basic dive profiles, type and length of menstrual bleed
  - Reported problems during diving (RPDD) were recorded via fixed option and free text responses
- Respondents were asked to complete menstrual records irrespective of whether or not they were diving during that particular month/cycle, and complete diving details irrespective of whether or not they were menstruating

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The menstrual cycle and diving: reported problems during diving (RPDD)

- Women were asked to detail any irregular aspect of a particular dive choosing from the series of fixed options which were *not* menstrual related
  - alcohol, illness, drugs, pushing tables/computer, visibility, buoyancy, cold, equipment, out of air, symptoms, and "none of these"
- There was also the opportunity to detail in their own words contributing reasons and factors for the RPDD

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The menstrual cycle and diving: reported problems during diving (RPDD)

- The length of every recorded cycle was known
  - not all cycles are of equal length
  - reported cycle lengths varied from <21 to >40 days
- Menstrual cycles were standardised into 28 days
  - The observed number of days from last menstrual period (LMP) to RPDD was transformed into a proportion of a 'standardised cycle length' of 28 days
- Respondents also recorded trouble-free dives
  - The standardising transformation was also used to give the phase in the cycle of all trouble-free dives

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The menstrual cycle and diving: reported problems during diving (RPDD)

- 570 women (533 menstruating) kept diving and menstrual diaries for periods of between 6 months and up to 3 years
  - regular updates on background data
  - basic details on all dives carried out
  - details of every menstrual cycle
- 61% women kept diving and menstrual diaries for the full three years!

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The menstrual cycle and diving: reported problems during diving (RPDD)

- Results at the *start* of the study
  - the age range was 14 to 57
  - the diving experience in years ranged from 1 to 34 years
  - dives logged ranged from 1 to 3,000
  - collective experience of >117,000 dives
  - 49% had dived to 40 meters or more
  - 49% had already logged >100 dives

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The menstrual cycle and diving: reported problems during diving (RPDD)

- During the time of the study:
  - >30,000 dive days were recorded
  - >50,000 dives were logged
  - 44% of diarists dived to 40 meters or more during the study
  - 174 metres was the deepest dive recorded!
  - 30% of diarists used the OCP
  - 95% continued to dive when menstruating
    - 8% of that group with more conservative profiles
  - >14,000 menstrual cycles were recorded
    - >7,000 with diving taking place

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The menstrual cycle and diving: reported problems during diving (RPDD)

- The 62% of women who recorded data for 3 consecutive years accounted for 83% of the dives recorded
  - averaged 40 dives each per year
- 65% of all women reported RPDD at some time whilst keeping diaries

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The menstrual cycle and diving: reported problems during diving (RPDD)

- The distribution of dives across the standardised menstrual cycle was uniform over the cycle for both OCP and non-OCP groups
- RPDD were not evenly distributed over the standardised menstrual cycle

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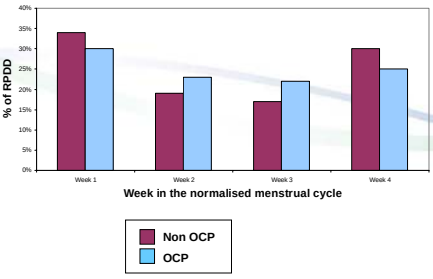
The menstrual cycle and diving: reported problems during diving (RPDD)



There was a significant, but non-linear, relationship between the standardised phase of the menstrual cycle and RPDD (p = 0.004)

The relationship with OCP usage and non-OCP usage was not significant (p-value = 0.098

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The menstrual cycle and diving: reported problems during diving (RPDD)

- Studies gathering data over the menstrual cycle have recruited women with regularly established 27 to 29 day cycles
  - or have *assumed* the participants to have a cycle covering days 0 to 29
- The length of every menstrual cycle by every woman in this study was known
  - this allowed an analysis of the rate of RPDDs in relation to the 'phase' in the cycle taking into account OCP and non-OCP usage for all the observed dives

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The menstrual cycle and diving: reported problems during diving (RPDD)

- By using the data for all menstrual cycle lengths we did not discard or ignore any of the information gathered
  - however, the rather simple transformation to phase based on the proportion of the observed cycle length may not produce the optimal measure of 'point in the cycle
- Despite this when the data from 28 day menstrual cycles are examined, the rates of RPDDs appear to follow *similar* trends to the full data set
  - for the non-OCP group *similar* peaks are seen at the start and end of the cycle

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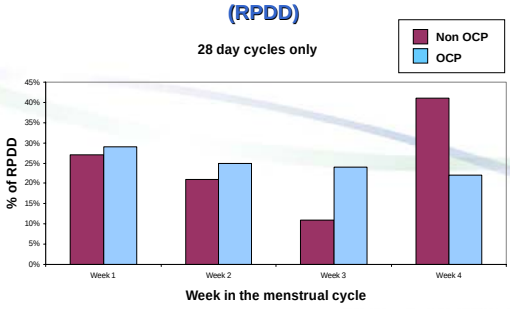
The menstrual cycle and diving: reported problems during diving (RPDD)



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The menstrual cycle and diving: reported problems during diving (RPDD)

- Are the incidents due to diving or menstruation?
- Studies in non diving women, observing human performance over the menstrual cycle, have been ambiguous in their findings

1. Hausmann M, Slabbekoorn, Van Goozen SH, et al. Sex Hormones Affect Spatial Abilities During the Menstrual Cycle. Behav Neurosci 2000 Dec;114(6):1245-50
2. Mumenthaler MS, O'Hara R, Taylor JL, et al. Relationship Between Variations in Estradiol and Progesterone Levels Across the Menstrual Cycle and Human Performance. Psychopharmacology (Berl) 2001 May;155(2):198-203
3. Maki PM, Rich JB, Rosenbaum RS. Implicit Memory Varies Across the Menstrual Cycle: Estrogen Effects in Young Women. Neuropsychologia 2002;40(5):518-29
4. Rosenberg L, Park S. Verbal and Spatial Functions Across the Menstrual Cycle in Healthy Young Women. Psychoneuroendocrinology 2002 Oct;27(7):835-41

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The menstrual cycle and diving: reported problems during diving (RPDD)

- The observed overall RPDD rate is 28.3 per 1000 dives
  - RPDD were not evenly distributed over the menstrual cycle
  - the rate is greater at the start of the cycle
  - falling during week three
  - rising again in week four.
- When analysing all the data, there was a significant relationship found between the standardised phase in the menstrual cycle and the rate of RPDD
- Although in this data set there is an overall difference in RPDD rates between women on the OCP and the women not on the OCP, this difference was not found to be statistically significant

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The menstrual cycle and diving: Decompression Illness (DCI)

V Lee, M St Leger Dowse, A Gunby, P Bryson

A collaborative study *QinetiQ* & DDRC

QinetiQ

The Hyperbaric Medical Centre (Diving Diseases Research Centre) DDRC

The menstrual cycle and diving: DCI

- The aim -
  - To investigate the presence of any relationship between the development of DCI, the phase in the menstrual cycle?

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The menstrual cycle and diving: DCI

Records were evaluated from 23 treatment chambers worldwide

Women had been physician 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

QinetiQ The Hyperbaric Medical Centre

The menstrual cycle and diving: DCI

Information gathered:

oral contraceptive pill use, usual length of menstrual cycle, age, depth of dive prior to onset of symptoms, type of symptoms, and smoking habits

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

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The menstrual cycle and diving: DCI

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 ($p<.01$)

For the OCP group there was no evidence against a uniform distribution using the Chi-square test

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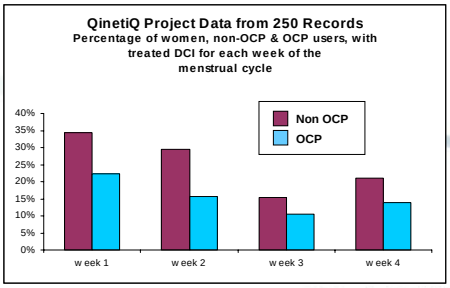
The menstrual cycle and diving: DCI



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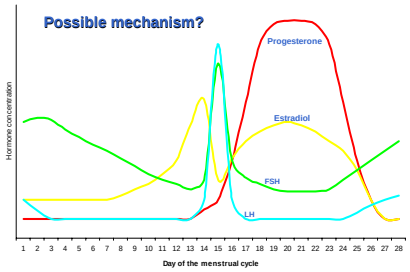
The menstrual cycle and diving: DCI



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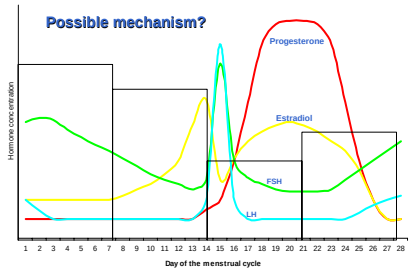
The menstrual cycle and diving: DCI



QinetiQ

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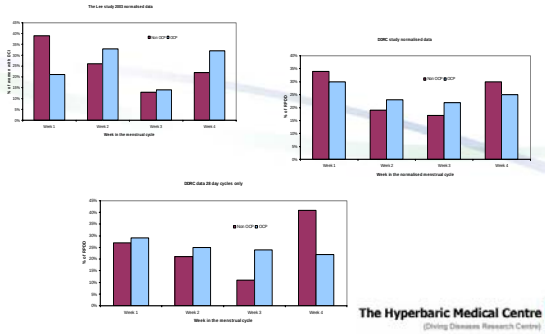
(Diving Diseases Research Centre)

The menstrual cycle and diving: RPDD and DCI



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The literature & conclusions

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.

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(Diving Diseases Research Centre)

The literature & conclusions

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

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(Diving Diseases Research Centre)

The literature & conclusions

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 Hyperbaric Medical Centre
(Diving Diseases Research Centre)

Pregnancy & Diving

M St Leger Dowse, A Gunby, R Moncad, C Fife, P Bryson

The aim:

To investigate any potential link between diving whilst pregnant and foetal abnormalities by evaluating field data

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(Diving Diseases Research Centre)

Pregnancy & Diving

Human retrospective studies

- 1978 Bangasser - (72) no abnormalities
- 1980 Bolton - (145) abnormalities, 5.5%
- 1985 Betts - (76) data too small, 3 in 30m depths
- 1989 Bakkevig - (34) data too small

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Pregnancy & Diving

Animal studies:

- Conflicting and contradictory in their findings
- May not be relevant to the human situation

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Pregnancy & Diving

Data gathered over ten years

- retrospective data (1990/2)
- prospective data (1996/2000)

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Pregnancy & Diving

- 129 females reported 157 pregnancies
- 1,465 dives whilst pregnant
- Mean age of 34 at 1st dived pregnancy

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Pregnancy & Diving

Retrospective	Prospective
35 weeks the latest time of diving	26 weeks the latest time of diving
65m deepest dive recorded	25m deepest dive recorded
92 dives recorded during one pregnancy	72 dives recorded during one pregnancy

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Pregnancy & Diving

Retrospective	Prospective
65% women ceased diving in 1st trimester	90% ceased diving in 1st trimester
12 women made 1st dive in 2nd trimester	26 weeks last time reported diving
1 women made 1st dive in 3rd trimester	

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Pregnancy & Diving

Retrospective	Prospective
65% women ceased diving in 1st trimester	90% ceased diving in 1st trimester
12 women made 1st dive in 2nd trimester	26 weeks last time reported diving
1 women made 1st dive in 3rd trimester	*Bolton Study (1980) 20% women still diving in 3rd trimester*

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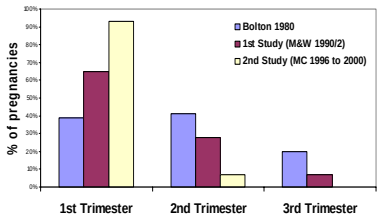
Pregnancy & Diving

FIG 1. Latest time of diving whilst pregnant



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Pregnancy & Diving

25% of 157 pregnancies failed to reach full term

- 1 still birth
- 16 terminations
- 22 spontaneous abortions

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Pregnancy & Diving

80% of 118 live births were perceived to be problem free

Problems reported with pregnancy or outcome ranged from “spotting up to 26 weeks” to low birth weight

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Pregnancy & Diving

Underlying variables likely to influence the findings?

- Age
- Drugs
- Alcohol
- Smoking
- Medical history
- Occupational activity
- Socio-economic grouping
- Geographical location
- Risk taking
- Other sports

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Pregnancy & Diving

Case 1 neonatal death 18 hours after delivery
The baby was diagnosed as suffering from "severe diaphragmatic hernia”
The respondent reported 10 dives in total
1 > than 20 metres, the last dive being in week 21
She also consumed alcohol during the pregnancy

Case 2 reported that her baby was born with an extra digit on the left hand - It was successfully tied off
She reported 13 dives, 4 in the 15 to 20 metres range between weeks 20 to 33
She consumed the occasional glass of wine with a meal whilst pregnant

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Pregnancy & Diving

Case 3 reported that she felt extremely ill during diving
After continuing to feel unwell during the pregnancy it was decided to terminate the pregnancy at 18 weeks
It was found that although the placenta appeared to indicate a pregnancy of 18 weeks, the foetus showed a size of 8-10 weeks
The respondent was also a sky diver and in the first 6 weeks of pregnancy had been to an altitude of 10,000 feet at least 6 times
She had dived to no more than 10 to 12 metres

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Pregnancy & Diving

Case 4 reported that her baby had a seizure at three days old a blood infection was suspected
The baby was full term and weighed 10lbs 10ozs
She reported 8 dives, 2 greater than 20 metres in the first trimester
She drank alcohol, 1 unit a day in the first trimester and thereafter 3 units per day 4 days a week
she also admitted to "occasional hashish" whilst pregnant

Case 5 was an active horse-back rider until the sixth month of her pregnancy, when she went into labour at 33 weeks
The baby weighed 3lbs 4oz
Her 10 dives took place in the 15 to 20 metres range up to week 20
It was concluded that the placenta had torn away, resulting in premature labour, following a fall from a horse
She did not drink alcohol or smoke during pregnancy

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Pregnancy & Diving

Retrospective

- 8 respondents on holiday in the early stages of pregnancy
- 5 pregnancies spontaneously aborted
- 4 of the 5 had dived 5 or 6 days in a row

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Pregnancy & Diving

Retrospective

- 8 respondents on holiday in the early stages of pregnancy
- 5 pregnancies spontaneously aborted
- 4 of the 5 had dived 5 or 6 days in a row

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Pregnancy & Diving

- Women are increasingly observing the recommendations
- "Do not dive if you are pregnant"
- Safe limits to dive whilst pregnant cannot be established by studying field data
- Animal data are not a good model on which to base recommendations
- The way forward remains elusive

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The future?

Scuba Diving & the Menstrual Cycle

What is the way forward? Further research?
Studies indicate a clear correlation between the incidence of DCI or RPDD and the point in the menstrual cycle
Data collection should include exact menstrual cycle lengths of both non-OCP and OCP users

Pregnancy and Diving

The risk of diving whilst pregnant remains un-quantified
It is unlikely that the safe limits to dive whilst pregnant will ever be established

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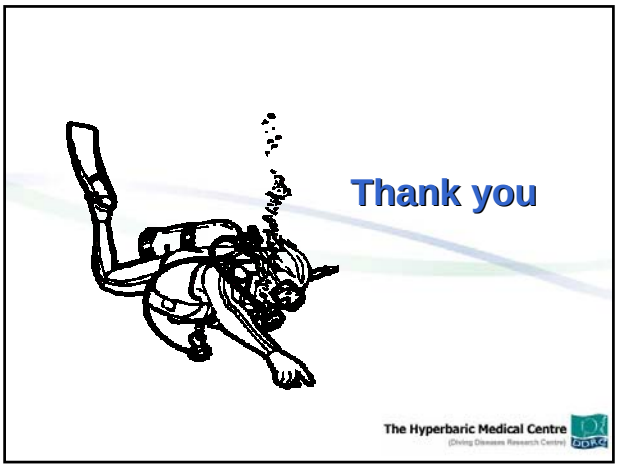
Thank you
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