DIVING DURING PREGNANCY

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ABSTRACT

It is at present not known if diving during pregnancy can damage the fetus. Very few studies on humans have been conducted on this topic, and the results and conclusions published are partly contradictory.

The present study has so far collected relevant information from 68 Norwegian and Swedish female sport divers with a total of 100 pregnancies. The mothers were diving during 34 of these pregnancies, and sustained from diving during 66 pregnancies.

The investigation was carried out as an interview survey using written questionnaires. The preliminary results show that five of the diving women gave birth to children with anomalies, which may or may not be related to diving. The corresponding number of anomalies in the non-diving group was one. The incidence of infant anomalies were thus approximately 15 and 1.5 per cent in the two groups respectively. Incidences of hemorrage during pregnancy, abortion, pre-term births and stillbirths were not significantly different in the two groups. Five of the diving women reported to have conducted dives with decompression stops during pregnancy. None of the diving women experienced decompression sickness.

Although the number of subjects included in the present investigation is rather limited, it seems fair to suggest as a preliminary conclusion, that diving during pregnancy should be discouraged or limited to a maximum depth of 10 metres.

INTRODUCTION

Previous findings related to the effects of diving on the fetus have been scarce and often contradictory, indicating that further research is needed regarding the safety of diving during pregnancy. Fetal development could be affected by:

- Diving (inert gas supersaturation + elevated PO_2)
- Fetal decompression sickness (bubble formation and chemical changes)
- Treatment of decompression sickness (DCS) using hyperbaric oxygen (elevated PO_2)

Potential problems associated with diving during pregnancy include the possibility of the mother and/or the fetus being exposed to bubble formation or DCS, Nitrogen bubbles in the developing fetus may create serious problems (7). Some of the physiological changes that occur during pregnancy include increased fat stores and body fluid retention, which may increase the susceptibility to decompression sickness of the mother.

Early experimental reports (12) suggested, however, that dog fetuses were more resistant than the mother to DCS. In sheep, whose placental circulation is more similar to the human, Fife et. al. (7) reported an even greater risk to the fetus than to the mother. This may be expected due to the presence of a fetal circulation with an open foramen ovale and ductus arteriosus (Botalli), which will allow the circulating venous bubbles in the fetus to pass directly into the fetal arterial blood. Stock (17) confirmed the findings of Fife, but showed that the increased risk to the fetus occured only in the fetus surgically prepared for the studies and that the fetus without surgery, were at no more risk than the mother. A more recent study on sheep (13) showed no bubbles in the fetuses, although bubbles were shown in the mothers. This study was done with an external doppler transducer.

Gilman et al. (9) indicated that repetitive no-stop decompression dives in hamsters during early organogenesis had no adverse effect on fetal development. The animals that did not develop symptoms of DCS had resorption and defect rates similar to the controls, and the fetuses from the dived hamsters showed no significant differences from the control group in birth weight, frequency of external malformation or death. However, they found teratogenic effects among the fetuses where the mother had suffered DCS early in pregnancy. It was suggested that DCS early in pregnancy may have significant deleterious effects on fetal development.

Wilson (19) found that six pregnant sheep who were decompressed according to US Navy diving manual after 20 minutes at 51 metres, delivered normally at or near term. One lamb was abnormal, but the relationship to the diving was unclear. On the other hand, out of six sheep who were decompressed without stops after the same exposure, three aborted dead fetuses and two others delivered mature, but affected lambs. The study indicated that staged decompression after hyperbaric exposures protected the fetuses from destructive effects of rapid decompression.

A more recent study (14) showed that the number of bubbles detected precordially in the mother, exceeded the number detected in the fetal umbilical artery for any given bottom time. Additionally, bubbles were found in the fetal circulation even when the mother did not display signs of DCS. They concluded that avoidance of symptoms of pain-only DCS in the mother is not sufficient to preclude gas phase formation in the fetus.

If the mother experiences decompression sickness, she may be treated with high pressure oxygen, which may present another problem for the fetus. Oxygen in high doses have been shown to cause teratogenic or lethal effects in animal fetuses (6,18). Although convincing data on human pregnancies are lacking, the animal experiments on hyperoxia and decompression should inspire caution.

Many women continue their usual diving activities during the first trimester not knowing that they are pregnant. Others continue to dive througout gestation as long *as* they feel comfortable. A safe maximum depth and duration time has not been established although there have been proposals from several different researchers. The recommendations vary from sustaining from diving altogether, to accept diving to maximum depths of 10-20 metres (3,4,8,10). Lanphier (11) recommended in a symposium on hyperbaric medicine and underwater physiology (1983) that:

"For the foreseeable future, women who are or may be pregnant should be advised to avoid diving. If they decide to contine diving, they should do so only under optimal conditions and with all appropriate precautions".

As the number of female divers are increasing and females also engage in professional diving, the responsibility is not only that of the pregnant women, but will also involve employers and insurance companies.

The aim of this study has been to collect available information on Scandinavian women sport divers who have a child birth behind, and who have, or have not been diving during pregnancy, and to map some of the factors that could affect the outcome of the pregnancies, such as their diving profile, incidence of DCS, smoking and drinking habits, etc.

MATERIAL AND METHODS

Questionnaires for the present study were published in Norwegian and Swedish diving magazines. In Norway, the questionnaires were also mailed to diving schools throughout the country, and to make sure that as many as possible of the women answered, these diving schools and diving clubs were later contacted by phone.

Altogether 68 Norwegian and Swedish women sport divers with a total of 100 pregnancies, have so far filled out the questionnaire. During 34 of these pregnancies the women were diving (Group D), while they sustained from diving during 66 of the pregnancies (Group ND). Although including only a small group of subjects, we feel that this study provides representative descriptive data on diving during pregnancy and prevalence of complications among Scandinavian female divers.

The data collected through the questionnaires cover the diving profile, potential gynecological problems such as vaginal bleeding during pregnancy, and the outcome, such as spontaneous abortion, low birth weight, still birth and/or birth defects. Cigarettes and alcohol consumptions as well as use of drugs were also covered. The questionnaire was of multiple choice type with some open-ended questions for additional information.

Chi-square analysis was used to determine probability levels of nominal data.

RESULTS

68 women responded to the questionnaires, some of whom had more than one pregnancy, therefore providing a total of 100 pregnancies. The women were diving during 34 of these pregnancies (Group D), and sustained from diving during 66 pregnancies (Group ND),

The women ranged in age from 21 to 45 years when responding; the average age was 29 years. Their average age while pregnant was 26 years. They had been diving anywhere from 1 to 18 years. The mean numbers of years of diving were 8.

The mean age of the diving mothers giving birth to children with birth defects was 25.6 years, not different from the average for the total group. The prevalence of complications is seen in Table 1.

GROUP	Number of. pregnancies	Vaginal bleeding	Spontaneous abortion	Low birth weight	Premature (<37 weeks)	Still birth	Birth defects
D*	34	3(8.8%)	1(3%)	-	3(8.8%)	-	5(15%)
ND**	66	7(10%)	-	1(1.5%)	1(1.5%)	1(1.5%)	1(1.5%)
Standard population	-	-	-	4.6%	5.8%	0.4%	1.0%

Standard population frequencies from National Board of Health and Welfare, Stockholm, Sweden.

D* = Diving ND** = Not Diving

Table 1. Prevalence of complications

The six recorded birth defects were Dysplasie coxae, Improper closure of gillpocket. Minimum brain damage. Epilepsy, Urinary malformation and Oesophagus atresi. If all the above mentioned anomalies are accepted as diving related, the frequency of anomalies in group D was 15% as compared to 1.5% in group ND (P > 0,0l). However, this numbers should be interpreted with caution.

Vaginal bleeding may be a sign of a threatening miscarriage. There were, however, no significant differences between the two groups regarding vaginal bleeding, neither were there any differences in spontaneous abortion, low birth weight, premature birth and stillbirth. Three of the women in group D reported such bleeding, and only one of these continued with an uneventfull pregnancy. Another of these three women had more than 10 dives deeper than 30 metres in the first trimester of which one was with decompression stops. She gave birth to a premature baby without any anomalies. This was the only premature birth in which the mother dived during pregnancy. The third woman with vaginal bleeding during pregnancy gave birth to a child with a defect.

One stillbirth was reported, but in this case the mother sustained from diving while pregnant. There was a report of a spontaneous abortion in the D group and none in the control group. Spontaneous abortion is defined as expulsion of the fetus within the first 24 weeks. The general frequency of spontaneous abortion is at least 25% and likely up to 40%. It is therefore assumed that additional abortions may have taken place without the women realizing it.

FETUS	TRIMESTER	Number of dives < 10m	11-20m	21-30m	>30m	Age of the mother when pregnant
No.l	FIRST		1-3			28
	SECOND					
No.2	FIRST			1-3		27
	SECOND					
No.3	FIRST			1-3		31
	SECOND					
No 4	FIRST				> 10	20
	SECOND	1-3				
No 5	FIRST		4 – 10			22
	SECOND		1 - 3			

Table 2. "Dive protocols" for the fetuses with birth defects (No. 1-5)

During 59% of the pregnancies in the D group, the mothers were diving only in the first trimester, while the rest continued during the second trimester. Six of the respondents made decompression stop dives while pregnant. However, none of the women participating in the investigation experienced DCS.

The sex ratio in the babies born in the two groups, varies whether their mother dived during pregnacy or not. Table 3.

	Mother diving	Mother not diving
Father diving	69% females 31% males (n = 29)	46% females 54% males (n = 37)
Father not diving	*	50% females 50% males (n = 23)

* Not recorded due to low number of samples

Table 3. Sex ratio in the babies born.

There were no difference in use of drugs, alcohol and smoking habits between the two groups. Six per cent in both groups were using drugs while pregnant; which were expected to not have any effects on fetus development.

The women were diving during the lactation period in 50% of the cases, and there seems to be no relationship between this and the milk production.

DISCUSSION

All retrospective studies on pregnancy and diving may be biased by a tendency of mothers who have had problems to be more prone to answer. In our material this was sought overcome through a direct contact with the diving clubs, to encourage all pregnant divers to respond.

In the present study, group D reported 15% physical anomalies in their babies, as compared to 1.5% in group ND (Table 1). If all the birth defects are accepted as related to diving, the incidence of anomalies among babies whose mothers dived during pregnancy was 10 times higher than the corresponding value for the control group. However, there may be doubts with respect to the etiology of some of the defects, possibly reducing this factor to as low as two. The value of the ND group corresponds well with that of the general public in Scandinavia, which is 1% (16).

Bolton (5) has also demonstrated increased prevalence of malformations among a retrospective sample of 136 women who dived during pregnancy, as compared to the control group where there was none. The frequency of malformation was, however, lower than in this study (5.5%) and within what she claimed to be the expected range for the general population in the U.S.A. Bangasser (2) on the other hand, have published that none of their 72 respondents reported any anomalies in their babies.

The main findings of a more recent English Diver survey (4) were that the incidence of diving related defects in 74 babies where the mother dived during various stages of pregnancy to depths less than 30 metres, was less than 2%. This corresponds to the incidence for the general public in Great Britain. However, among the ten women who dived beyond 30 metres in the first trimester, three of the babies were born with congenital anomalies, giving an incidence of 30%.

As can be seen from Table 2, the mothers of the babies with anomalies of the present study, had all been diving in the first trimester. Two of the mothers were diving to a maximum depth of 20 metres, two to 30 metres, and one was frequently (>10 times) diving deeper than 30 metres.

Of the 34 pregnancies in group D, 11 had been diving deeper than 20 metres and three deeper than 30 metres. The corresponding prevalence of anomalies were approximal 30% in both groups. This supports the findings of Betts (4) referred to above, and, although based on a very small number of observations, also indicates that the prevalence of anomalies may start increasing at diving depths even shallower than 30 metres.

The number of anomalies recorded in babies born by diving women in the present study, is much higher than that reported by other investigators. The reason for this is not obvious. Diving in the cold Scandinavian waters may imply more stress than diving in warm waters. Dry suit with weight belts are a heavy load on land before and after dives. Cooler water also represent a thermal stress with possible effects on inert gas handling by the body. Whether these factors could also have an effect on the prevalence of anomalies can only be open for speculation at the present time.

The percentage of the pregnant females who continued diving during pregnancy, were reported by Bolton (5) and Bangasser (2) to be 65 and 70%, respectively. In our material there tends to be a difference between Swedish (20% continued) and Norwegian women (47% continued). This might be a result of the fact that the Swedish material is collected during 1989, while the Norwegian data is up to four years old. This may imply a general tendency to be more careful and avoid diving as more attention has been put on possible negative effects of diving during pregnancy.

Rockert (15) has reported that among 60 children of 34 Swedish navy divers only 20 were boys, and Bachrach and Holiman (1) have reported that among members of the US Navy Divers Association the girl/boy ratio was 165/173 before the fathers started to dive and 341/265 during active diving. The present study has not been able to confirm these findings. As can be seen in Table 3, the data recorded in this study showed no predominance of girls as compared to boys, when the father only was diving. When the father and the mother was diving, however, a marked decrease in relative numbers of boys were recorded.

CONCLUSION

The available information indicate that the risk for birth defects increased if the pregnant women continued diving. Not all the answers are yet known, and research on the pregnant diver should continue. However, if the pregnant diver limits her dives to 10 meter, the possibility that

high nitrogen or oxygen partial pressures or supersaturation following decompression should cause harm to the fetus is probably low.

Based on the data in this study, the authors thus recommend either not diving or keeping the dives shallower than 10 metres.

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