Extremely low frequency magnetic fields and fertility: a follow up study of couples planning first pregnancies

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Abstract

***Objectives*—To evaluate the impact of extremely low frequency (ELF) magnetic fields on markers of human fertility.**

***Methods*—A follow up study of time to pregnancy, semen quality, and reproductive hormones was conducted among couples planning first pregnancies (36 males were welders and 21 were non-welders). The male and the female partner were monitored for exposure to ELF magnetic field by personal exposure meters. As summary measures of exposure the median value was calculated together with the 75 percentile value and the proportion of measurements exceeding 0.2 and 1.0 µT, respectively. Each summary measure was divided in three categories: low, medium, and high.**

***Results*—Couples in which the man had a medium or a high proportion of measurements >1.0 µT had a reduced probability of conception per menstrual cycle compared with the men with low exposure, but the result was only significant for the men with medium exposure. This finding was partly attributable to a high probability of conception per menstrual cycle among the men with low exposure compared with non-welders in the original cohort of 430 couples. Other summary measures were not related to probability of conception or other markers of fertility. A possible negative association was found between high probability of conception and female exposure measures based on the median, the 75 percentile, and the proportion of measurements >0.2 µT, but no association was found with the proportion of measurements >1.0 µT.**

***Conclusions*—The findings provide no consistent support for a hypothesis of a deleterious effect of low level ELF magnetic fields on markers of human fertility. However, due to the relatively small size of the studied population only large associations would be detected.**

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A possible detrimental effect of metal welding on male fertility has been the subject of several studies during the past decades.[1–10] Metals such as hexavalent chromium in welding fume and radiant heat from the welding process, may constitute potential hazards.[11] Electric arc welding is associated with exposure to extremely low frequency (ELF) magnetic fields, which may influence reproductive functions as well.[12–15] The aim of this study was to evaluate the impact of ELF magnetic fields on markers of fertility in a follow up study of couples planning first pregnancies.

Methods

From 1992 to 1994 a total of 430 couples was recruited by nationwide mailing of a personal letter to 52 255 trade union members (metal workers, office and commercial workers, nurses and day care workers) who were aged 20–35 years, living with a partner and had no children. Only couples without previous reproductive experience who intended to discontinue contraception to become pregnant were eligible for enrolment. The couples were enrolled into the study when they discontinued birth control. Each men provided a fresh semen sample and blood samples were drawn from both partners. The couples were followed up for 6 menstrual cycles or until a pregnancy was recognised by the general practitioner. During follow up the woman kept a diary in which she recorded vaginal bleeding and sexual intercourse. A detailed description of cohort and methods are provided elsewhere.[16]

Measurements of extremely low frequency (ELF) magnetic fields were included in the protocol from January 1994, and 306 couples enrolled after this date were candidates for the monitor program, but due to a limited number of exposure meters only three couples could be monitored at the same time. The couples were selected independently of any markers of fertility, but preference was given to couples in whom the man was a metalworker. Of 87 selected couples 28 refused to be monitored, mainly because they did not want colleagues or employers to know that they were planning a pregnancy, and two recordings were lost for

Table 1 Summary measures of exposure to ELF magnetic fields among male welders and non-welders (median (range))*

Summary exposure measure	Welders (n=22)	Non-welders (n=35)
Measurement value:		
Median (µT)	0.04 (0.01 to 0.15)	0.04 (0.01 to 0.11)
75th Percentile (µT)	0.08 (0.02 to 0.31)	0.09 (0.02 to 0.23)
Proportion>0.2 µT (%)	7.1 (2.0 to 43.5)	5.9 (0.4 to 35.8)
Proportion>1.0 µT (%)	1.7 (0.04 to 14.3)	0.4 (0.0 to 7.1)

*Electric arc welding during the three day monitoring period.

Table 2 Fecundability and median values of semen parameters and sexual hormones according to four summary measures of male exposure to ELF magnetic fields

		Outcome	Semen variables			
		Fecundability (%)	Sperm density (10^6/ml)	Count (10^6)	Morphology (% normal)	Motility (% non-motile)
n		225 cycles	57	57	57	57
(Percentiles 25, 50, and 75)			(28,60,112)	(102,206,343)	(33,41,46)	(26,33,40)
Measurement value:						
Median (µT):						
Low	0.01–0.03	18.5	60	226	43	31
Medium	0.03–0.05	18.4	76	185	40	39
High	0.05–1.15	13.2	52	206	38	27
75 Percentile (µT):						
Low	0.02–0.06	18.1	84	226	43	31
Medium	0.06–0.10	15.2	52	120	40	34
High	0.10–0.31	17.4	68	240	41	32
Proportion >0.2 µT (%):						
Low	0.04–4.75	18.2	76	185	41	36
Medium	4.75–9.70	17.3	48	206	44	32
High	9.70–43.5	15.1	68	240	38	32
Proportion>1.0 µT (%):						
Low	0.0–0.27	25.4	52	180	40	34
Medium	0.27–1.25	12.5	84	252	46	33
High	1.25–14.3	14.9	58	240	40	31

technical reasons. Recordings were available for 57 men, and in 52 cases recordings were also available for the female partner. Of the men, 36 had reported welding during the past 3 months before enrollment, 13 were non-welding metal workers, and eight were non-metal workers.

Exposure to ELF magnetic fields was measured with personal exposure meters during 60 hours (3 work days and 2 nights). Both the male and the female partner was equipped with an exposure meter for the 0.01–70 µT range (Emdex Lite Standard). The male partner was furthermore equipped with another meter for the 1–7000 µT range (Emdex Lite high field). During daytime the instruments were placed in a leather case attached to a belt worn at the right side of the waist. During the night the meters were placed nearby, but at least 0.5 m from electric clocks and other electrical installations. Further details are given elsewhere.[17] For each participant the median recorded value was calculated together with the 75th percentile value and the proportion of measurements >0.2 and >1.0 µT. The median values of each summary measure are presented in table 1. Each measure of exposure was divided into three roughly equal sized categories, for each sex separately: low, medium, and high. Fecundability, defined as the probability of conceiving in a menstrual cycle of unprotected intercourse,[18 19] was analysed in logistic regression models while controlling for cycle number. This model is equivalent to the discrete version of Cox's proportional hazard model.[20 21] Sperm density and sperm count were analysed in linear regression models with the semen variables transformed to the third root. Sex hormones were analysed with distribution free methods (Wilcoxon's signed rank sum test).

Table 3 Fecundability and median values of mean duration of menstrual cycle and sexual hormones according to four summary measures of female exposure to ELF magnetic fields

		Fecundability (%)	Menstrual cycle duration (days)
n (Percentiles 25, 50, and 75)		215 cycles	52 (28,28.5,33.5)
Measurement value:			
Median (µT):			
Low	0.01–0.03	23.1	28.0
Medium	0.03–0.05	17.7	30.0
High	0.05–0.24	13.4	29.0
75 Percentile (µT):			
Low	0.01–0.06	23.8	28.0
Medium	0.06–0.12	14.3	30.0
High	0.12–0.32	15.9	29.0
Proportion>0.2 µT (%):			
Low	0.3–2.75	24.1	28.0
Medium	2.75–10.1	13.4	29.0
High	10.1–55.3	17.3	29.0
Proportion>1.0 µT (%):			
Low	0.0–0.15	16.3	28.0
Medium	0.15–0.35	19.2	30.0
High	0.35–3.6	18.1	28.5

Results

The fecundability was unrelated to the exposure measures of the men to ELF magnetic fields: the median; the 75 percentile; and the proportion of measurements >0.2 µT (table 2). However, the fecundability of couples in which the man had a low proportion of measurements >1.0 µT was higher than the rest. The fecundability odds ratio (OR) compared with the group with low exposure was 0.4 (95% confidence interval (95% CI) 0.2 to 0.9), and 0.5 (95% CI 0.2 to 1.2) for the men with the medium and highest exposure. After adjustment for potential confounders (cycle number, centre, age, body mass index, contraceptive method, self reported male or female genital disorder, female smoking, caffeine and alcohol consumption) the ORs were 0.3 (0.1 to 1.0) and 0.7 (0.2 to 2.1), respectively. No differences were found in internal comparisons of semen variables (table 2) and hormones within any exposure measure (data not shown).

The fecundability was not related to the proportion of measurements >1.0 µT in the women, but women with low exposure according to the other three measures had a higher fecundability than the rest (table 3). These results were, however, not significant. After adjustment a significantly reduced fecundability was found in women with a medium proportion of measurements >0.2 µT, but not in women with a high proportion. Compared with women with the low exposure the ORs were 0.2 (0.1 to 0.7) and 0.3 (0.1 to 1.1), respectively. Exposure of women to ELF was not related to differences in duration of the menstrual cycle (table 3) or sexual hormones (luteinising hormone, follicle stimulating hormone, oestradiol, and testosterone (data not shown)).

The sample size was too small for analyses of spontaneous abortions, but in an additional analysis of fecundability we defined a success as a live born child instead of a clinically recognised pregnancy. In this analysis the fecundability OR of couples in which the man had a high proportion of measurements >1.0 μT dropped to 0.3 (0.1 to 0.8) for medium exposure and 0.4 (0.2 to 1.1) for high exposure. The risk estimates for female ELF exposure changed only marginally.

Discussion

Metal workers constituted 86% of the participants and reported welding 5.8% of the time during work, half of them did not weld at all during the 3 days. Compared with a group of shipyard welders, who reported welding for 56% of the time during a similar monitoring programme, our participants had low exposure to ELF magnetic fields.[17]

The only significant association between ELF magnetic fields and male markers of fertility was found between the proportion of measurements >1.0 μT and the fecundability. However, this finding was partly attributable to a relatively high fecundability among the men with low exposure (25.4% compared with 15.6% among non-welders in the original cohort of 430 couples). In an exposure study with the same protocol it was found that a reading of >1.0 μT was indicative of welding,[17] and in a previous report of the impact of electric arc welding on fecundability based on the entire group of 430 couples, a reduced fecundability was found in welders, although this was only significant among smokers.[10] Thus, the present finding could also be explained by for example, welding smoke or high temperature as well, irrespective of ELF magnetic fields.

For ELF exposure in the women the associations were found in the complementary exposure measures so that a possible negative association was found between fecundability and exposure measures based on the median, the 75th percentile, and the proportion of measurements >0.2 μT, but no association was found for the proportion of measurements >1.0 μT.

In conclusion, our findings provide no consistent support for a hypothesis of a deleterious effect of low level ELF magnetic fields on markers of human fertility. However, due to the relatively small size of the population studied only large associations would be detected.

The Danish First Pregnancy Planner Study is a collaborative follow up study on environmental and biological determinants of fertility. The project is coordinated by the Steno Institute of Public Health, University of Aarhus and is undertaken in collaboration with the Department of Growth and Reproduction, National University Hospital in Copenhagen. The team includes Jens Peter E Bonde, Niels Henrik I Hjollund, Tina Kold Jensen, Tine Brink Henriksen, Henrik A Kolstad, Erik Ernst, Aleksander Giwercman, Niels Erik Skakkebæk, and Jørn Olsen. This study was mainly supported by a grant from Aarhus University Research Foundation (1994–7430–1), but additional support was also given by the Danish Medical Research Council (12–2042–1) and the Danish Medical Heath Insurance Foundation (11/243–91 and 11/236–93). The couples are acknowledged for their enthusiasm in making this study possible. We are indebted to support from several trade union officials, in particular Ernst Bliesmann, Peter Olesen, Rigmor Laulund, and Niels Nedergaard.

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