

Biological Hazard of Occupational Exposure To  
Electromagnetic Fields

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Genetic

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## Summary

The present study aims at determining the potential genetic damage of occupationally exposure to EMF. The studied subjects are engineers and air traffic controllers exposed to radiofrequency EMF emitted from different instruments. The level of EMF to which the subjects were exposed ranged from 60.43% to more than 105.7% of ANSI standard (American National Standard Institute).

The potential genetic damage was measured by the increase in number of cells with chromosomal aberrations (Structural and numerical) and the frequency of sister chromatid exchanges SCEs compared to a control group. The effect on mitotic activity and the cell cycle kinetics were also investigated. The duration of exposure and smoking habits of occupationally exposed individuals were also considered in the present study.

The results show that the percentage of aberrant cells with structural chromosomal aberrations was 2.85% in engineers and 2.42% in air traffic controllers whereas in the control group it was 0.40%. such increase was statistically significant at  $p < 0.01$  for the exposed engineers and air traffic controllers. The percentage of cells with total numerical aberrations were 9.62% , 9.17% and 3.20% in engineers, air traffic controllers and control individuals, respectively.

In order to study the effect of duration of exposure, the engineers and the air traffic controllers were further subdivided into two subgroups according to their average exposure times which was 20 in engineers and 16 in air traffic controllers. The percentage of cells with structural chromosomal aberrations was 3.29% and 2.33% in engineers exposed to EMF for  $\geq 20$  and  $< 20$  years, respectively. The increase in cells with

structural and numerical aberrations in both groups were statistically significant at  $p < 0.001$  when compared with the control. No significant effect was found between engineers exposed for  $\geq 20$  and those exposed for  $< 20$  years.

In air traffic controllers the percentage of cells with structural chromosomal aberrations were 2.77% and 2% in individuals exposed for  $\geq 16$  and  $< 16$  years, respectively. These increase were significant at  $p < 0.001$  and  $p < 0.05$ , respectively when compared with the control group (0.4%). The corresponding percentages in cells with total numerical aberrations were 9.38 % and 8.91% respectively. The increase were significantly different from the control. No significant effect was found between air traffic controllers exposed for  $\geq 16$  and those for  $< 16$  years.

Statistical analysis also showed that there is no significant difference in the frequency of the total structural and numerical chromosomal abnormalities between the smoking and non smoking groups of both engineers and air traffic controllers.

The rate of lymphocyte proliferation, expressed by the mitotic index (MI) in EMF- exposed individuals and control groups were reported. A decrease in MI is reported in EMF exposed engineers ( $19.56 \pm 5.92$ ), and air traffic controllers ( $18.58 \pm 5.28$ ) compared to the control group ( $30.20 \pm 13.29$ ). This decrease was statistically significant at  $p < 0.01$  and  $p < 0.001$  in engineers and air traffic controllers respectively.

The mitotic indices were ( $17.18 \pm 4.49$ ) and ( $22.3 \pm 6.35$ ) in engineers exposed to EMF for  $\geq 20$  years and  $< 20$  years respectively. A decrease in the mitotic activity was only significant ( $p < 0.01$ ) in engineers exposed for  $\geq 20$  when compared with control group ( $30.20 \pm 13.09$ ). In

air traffic controllers exposed to EMF the mitotic indices were  $18.42 \pm 3.11$  and  $18.77 \pm 7.24$  in individuals exposed for  $\geq 16$  years and those exposed for  $< 16$  years respectively. The mitotic activities of both subgroups were significantly reduced at  $p < 0.01$  and  $p < 0.05$ , respectively compared to the control group. No significant effect was found between air traffic controllers exposed for  $\geq 16$  and those for  $< 16$  years. The decrease in mitotic index in exposed workers regarding their smoking habit were  $20.00 \pm 7.36$  and  $19.32 \pm 5.24$  for smoking and non-smoking engineers, respectively. Whereas in air traffic controllers the MI were  $20.88 \pm 7.62$  and  $17.44 \pm 3.38$  in smoking and non-smoking subgroups, respectively. The differences between smoking and non-smoking subgroups did not reach statistical significant levels.

As for SCE parameter, the results show that the frequencies of SCEs in control group, engineers and air traffic controllers were  $4.5 \pm 0.94$ ,  $5.00 \pm 1.20$  and  $4.80 \pm 1.25$  SCEs/cell respectively. Although there was a slight increase in exposed groups over the control such increase was not statistically significant. The frequencies of SCEs were  $5.23 \pm 1.52$  and  $4.47 \pm 0.96$  SCEs/cell for engineers exposed to EMF for  $\geq 20$  years and for  $< 20$  years, respectively. The frequencies of SCEs were  $4.67 \pm 1.35$  and  $4.77 \pm 1.23$  SCEs/cell in air traffic controllers worked for  $\geq 16$  years and  $< 16$  years, respectively. No statistical significant difference was found regarding duration of exposure.

Regarding the smoking habits, the frequencies of SCEs were  $4.58 \pm 1.09$ ,  $5.2 \pm 1.27$ ,  $4.49 \pm 1.05$  and  $4.8 \pm 1.37$  SCEs/cell in smoking and non smoking engineers and smoking and non smoking air traffic controllers, respectively. No statistical significant difference is found between exposed workers in relation to their smoking habits.

The cell kinetics expressed as the replicative index (RI), were  $1.78 \pm 0.180$ ,  $1.79 \pm 0.180$  and  $1.80 \pm 0.21$  for control, engineers and air traffic controllers, respectively. Statistical analysis showed that exposure to EMF did not affect the RI in both exposed groups when compared to the control group.

The mean RI in exposed engineers worked for  $\geq 20$  and for  $<20$  years were  $1.75 \pm 0.12$  and  $1.82 \pm 0.22$ , respectively. Whereas the mean of RI in air traffic controllers exposed to EMF for  $\geq 16$  years and for  $<16$  years were  $1.8 \pm 0.24$  and  $1.82 \pm 0.19$  respectively. No statistical difference was found in both exposed groups compared to the control. Also, no significant difference was found in relation to duration of exposure and smoking habits.

In conclusion, that exposure to RF, under the present conditions lead to genotoxic effects independent from duration of exposure and smoking habits. These effects were in the form of increase in structural chromosomal aberrations, increase in numerical chromosomal aberrations and decrease in rate of cell division. However, no elevation in sister chromatid exchanges or changes in cell cycle kinetics in human lymphocytes from individuals occupationally exposed to EMF have been recorded.