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Occupational exposure to electromagnetic fields: workers at particular risk and indications for health surveillance

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Abstract

Occupational exposure to electromagnetic fields (EMF) is almost ubiquitous nowadays in industrialized countries. Specific work-related risks may involve the exposed workers and accordingly an adequate health surveillance (HS) program is required, especially for the so called "workers at particular risk".
In EU, the HS of workers exposed to EMF is mandatory based on the Directive 2013/35/EU.
The EU Directive specifically addresses the prevention of direct biophysical effects and indirect effects of EMF exposure. These latter effects include interference and the risk can be relevant in case of presence of workers with Active Implanted Medical Devices (AIMD) and/or with Active Wearable Medical Devices (AWMD), even in conditions of exposure levels below the recognized limits to protect the general public. Accordingly, the medical examinations within the HS program should carefully look for the presence of AIMD and AWMD, as well as for possible signs of over-exposures.

1. Introduction

Occupational exposure to electromagnetic fields (EMF) is almost ubiquitous nowadays in industrialized countries [1]. Specific work-related risks may involve the exposed workers and accordingly an adequate health surveillance (HS) program is required, especially for the so-called "workers at particular risk" and in case of over-exposure [1,2].

2. Methods

In EU, the HS of workers exposed to EMF is mandatory based on the Directive 2013/35/EU. Considering the available indications and a survey among Occupational Physicians (OPs), we identified the main criteria to be considered for an appropriate HS, as well as for the identifications of the "workers at particular risk" for EMF exposure, as defined by the Directive.

3. Results

The EU Directive specifically addresses the prevention of direct biophysical effects and indirect effects of EMF exposure. These latter effects include interference and the risk can be relevant in case of presence of workers with Active Implanted Medical Devices (AIMD) and/or with Active Wearable Medical Devices (AWMD), even in conditions of exposure levels below the recognized limits to protect the general public (Table I). Accordingly, the medical examinations within the HS program should carefully look for the presence of AIMD and AWMD: the most frequent devices resulted the cardiac pacemakers (PM) and implantable cardioverter defibrillators (ICD) for AIMD, while drugs/hormones infusion pumps and hearing aids for AWMD.

Table I. Non-Exhaustive List of Active Implanted and Wearable Devices possibly subjected to interference in workers exposed o EMF

Active implanted medical devices (AIMD)	Cardiac pacemakers, Implantable cardioverter-defibrillators, Loop Recorders, Cochlear implants, Brainstem implants, Inner ear prostheses, Central and/or Peripheric Neural System Stimulators, Retinal encoders, Implanted drugs/hormones infusion pumps
Active Wearable Medical Devices (AWMD)	Implanted drugs/hormones infusion pumps, Hearing aids, Continuous glucose monitoring systems, Active musculo-skeletal prosthesis and exoskeletons

4. Discussion

In the European Union an obligation for the HS of EMF exposed workers is provided by the Directive 2013/35/EU, also identifying Exposure Limits Values (ELVs) for occupational exposures. The HS is aimed to protect and to promote the workers' health. The EU Directive specifically addresses the prevention of EMF direct biophysical effects (as stimulation of muscles, nerves or sensory organs, or thermal effects) and indirect effects (as interference). Conversely, long-term effects are not addressed as scientific evidence of a causal relationship is considered

inadequate. Occupational EMF-exposures lower than the ELVs can be usually considered adequately protective against the direct effects, but the occurrence of groups of "workers at particular risk", including subjects with AIMD and/or AWMD, must be considered, and adequate prevention provided. To date no laboratory tests or specific medical investigations can be considered adequate in terms of validity and performance.

Among AIMD, the most studied devices, with concern to possible electromagnetic interference problem, and also considering that are the most frequently occurring in workers, are PM and ICD. Available data suggest that interference problems may occur, but are reversible and fortunately clinically silent, and could be discovered during the periodic clinical checks of the devices [3]. Also AWMD are frequent and can be possibly affected by electromagnetic interference: according to our survey among OPs, external hearing aids and drugs/hormones infusion pumps can be found in about the 0.5% of the working population. To date, there is scant data on the reporting of possible interference issues in case of occupational EMF exposure for these devices.

Finally, it should be mentioned that the EU Directive specifically requires a medical examination in case of occupational exposure exceeding the ELVs or in case of workers reporting undesired or unexpected health effects, possibly associated with EMF interactions through a direct biophysical mechanism (Table II). These circumstances need to be addressed in the workers' HS programs, planning appropriate medical checks.

Table II. Effects associated with over-exposure to electromagnetic fields based on biophysical thermal or non-thermal mechanisms.

Type of EMF	Type of Effects	
	Sensory Effects	**Health Effects***
Static magnetic fields	Vertigo, nausea, perception of a metallic taste in the mouth	Altered blood flow in limbs, altered brain function, altered heart function (e.g. altered blood flow or cardiac rhythm)
Low-frequency fields	Magnetophosphenes, minor changes in brain function, tingling sensation due to the stimulation of the nerves	Pain due to the stimulation of the nerves, involuntary contractions of the muscles, alterations of the cardiac rhythm
Intermediate-frequency fields	Effects of both high and low frequencies can be experienced	The effects of both high and low frequencies can be experienced
High-frequency fields	Microwave auditory effects, microwave stimulation of nerves/receptors in the skin	Excessive increase in temperature or thermal burns over the whole body or in specific areas, thermal damage at the eyes (possibility of thermal cataracts) or skin
***NB: effects possible only in case of extremely high exposure levels, largely above the occupational exposure limits**		

5. Conclusions

Particular risks as the conditions of workers with AIMD or AWMD have to be carefully considered and assessed for the HS programs of subjects with occupational EMF exposure. Specific medical examinations should be warranted also in case of over-exposures and for those workers experiencing direct biophysical effects.

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