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Health Surveillance of Personnel Occupationally Exposed to Microwaves. II. Functional Disturbances

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The incidence of functional disturbances (neurotic syndrome, gastro-intestinal tract disturbances, cardio-circulatory disturbances with abnormal ECG) was analysed in 841 males aged 20 to 45 years, occupationally exposed to microwaves for various periods of time. The whole population was subdivided into two groups differing only in respect to microwave exposure—low i.e. below 0.2 mW/cm² and high i.e. between 0.2 mW/cm² and 6 mW/cm². No dependence of the incidence of functional disturbances on the exposure level or duration of occupational exposure (years) could be demonstrated.

VARIOUS FUNCTIONAL disturbances in the nervous and cardiocirculatory systems were described in persons occupationally exposed to microwaves (MW) by numerous authors (see 1 and 3 for references). The opinions about the causal relationship of such disturbances to MW exposure, as well as to their significance for determination of the fitness for work in MW exposure conditions, differ. In view of this it seemed interesting to make an attempt at a statistical analysis of the incidence of such disturbances in a selected group of MW workers.

MATERIALS AND METHODS

A selected group of 841 males aged 20 to 45 years occupationally exposed to MW during various periods of time was examined. The whole population worked in identical conditions, differing only in MW exposure levels. According to these, the examined population was subdivided into two groups: group I numbering 507 individuals exposed to mean power densities above 2 W/m² (0.2 mW/cm²) reaching up to 60 W/m² (6 mW/cm²) during short periods of time, according to Polish rules about safe exposure limits; and group II numbering 334 individuals exposed to mean power den-

sities below 2 w/m². The results of medical examinations were compared between both groups and within each group, subdivided according to age or the duration of occupational exposure. The rationale of such an approach is that no adequate control group identical in working conditions and socio-economic status could be found for the whole population of MW workers. Group I and II are comparable in all respects, save the level of MW exposure; this may be considered relatively insignificant in group II, which serves as control for group I. Details on health surveillance, working conditions, structure of both groups in respect to age and duration of occupational exposure as well as methods of statistical analysis were described in a previous paper (2).

RESULTS

The incidence of functional disturbances and the criteria for their recognition: The health status of the examined individuals was: 1) showing no functional disturbances, 2) neurotic syndrome, 3) digestive tract functional disturbances and 4) cardio-circulatory disturbances with abnormal ECG findings. The incidence of each of these four health status categories was examined in each group, compared between groups, and analysed within each group, according to age and duration of occupational exposure. The results are shown in Tables I to IV. The comparison between groups demonstrates that the difference in exposure levels did not influence the incidence of functional disturbances, nor does it depend on duration of occupational exposure. The incidence of functional disturbances depends in group I on age; this relationship was shown to be non-linear.

It should be, however, stressed that in about 60% of all examined individuals functional disturbances were found and in about 30% of cases the severity of symptoms was thought sufficient to declare the persons concerned unfit for further work in conditions of MW exposure.

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TABLE I. COMPARISON OF CORRESPONDING VALUES IN GROUP I AND II SUBDIVIDED ACCORDING TO AGE (MEAN PERCENT ± STANDARD DEVIATION).

Functional disturbances	Group I	Group II	I T I	F
none	37.2 ± 11.7	34.3 ± 11.8	0.605	1.015
neurosis	34.2 ± 9.6	31.8 ± 6.0	0.738	2.549
digestive tract	19.7 ± 6.5	23.5 ± 8.5	1.236	1.721
abnormal ECG	8.8 ± 3.4	10.4 ± 3.3	1.154	1.018

$n_1, n_2 = 12$ $k = 22$ $f_1, f_2 = 11$ Verified I T I with $t_{0.05;22} = 2.074$
 F with $F_{0.05;11;11} = 2.850$

Explanation: n = number of results; I T I = t test (Student's test) module;
 k = degrees of freedom; F = F number (Fisher's test); f = degrees of freedom.

TABLE II. COMPARISON OF CORRESPONDING VALUES IN GROUP I AND II SUBDIVIDED ACCORDING TO DURATION OF OCCUPATIONAL EXPOSURE (MEAN PERCENT ± STANDARD DEVIATION).

Functional disturbances	Group I	Group II	I T I	F
none	38.4 ± 17.8	30.4 ± 9.5	1.635	3.546
neurosis	35.1 ± 9.7	34.2 ± 8.4	0.288	1.334
digestive tract	21.6 ± 9.3	22.9 ± 8.4	0.429	1.222
abnormal ECG	8.2 ± 4.5	11.4 ± 5.5	1.272	1.478

$n_1, n_2 = 17$ $k = 32$ $f_1, f_2 = 16$ Verified I T I with $t_{0.05;32} = 2.042$
 F with $F_{0.05;16;16} = 2.350$

Explanations see table I.

TABLE III. ANALYSIS OF THE DEPENDENCE OF THE INCIDENCE OF FUNCTIONAL DISTURBANCES ON AGE AND DURATION OF OCCUPATIONAL EXPOSURE IN GROUP I.

Functional disturbances	Duration of occupational exposure, yrs			Total	Age, yrs			
	1-5	6-10	10 or more		20-25	26-30	31-35	36-45
none	83	68	39	190	63	58	26	43
neurosis	64	78	38	180	38	64	49	29
digestive tract	26	38	23	87	10	23	24	30
abnormal ECG	20	23	7	50	14	13	10	13

$P_2 = 0.25243$ $\chi^2 = 7.80899$ $k_2 = 6$ $\phi = 0.01540$ $K = 0.00629$
 $P_2 = 0.00010$ $\chi^2 = 33.71979$ $k_2 = 9$ $\phi = 0.06651$ $K = 0.02217$

TABLE IV. ANALYSIS OF THE DEPENDENCE OF INCIDENCE OF FUNCTIONAL DISTURBANCES ON AGE AND DURATION OF OCCUPATIONAL EXPOSURE IN GROUP II.

Functional disturbance	Duration of occupational exposure, yrs			Total	Age, yrs			
	1-5	6-10	10 or more		20-25	26-30	31-35	36-45
none	50	31	27	108	32	22	21	33
neurosis	40	41	35	116	23	25	20	48
digestive tract	29	33	16	78	10	14	19	35
abnormal ECG	15	9	8	32	8	6	5	13

$P_2 = 0.31456$ $\chi^2 = 7.06852$ $k_2 = 6$ $K = 0.00864$ $\phi = 0.02116$
 $P_2 = 0.27817$ $\chi^2 = 10.96428$ $k_2 = 9$ $K = 0.01094$ $\phi = 0.03283$

The criteria of recognition of what is called here a neurotic syndrome were as follows: fatigue unproportional to effort, frequent headaches, sleep disturbances, emotional instability, inability to concentrate, difficulties in memorizing, and in certain instances decrease of sexual potency. These complaints and psychologic examination findings were accompanied by symptoms of vegetative system overexcitability, red dermographism, tremor of hands, sweating and hyperreflexes on neurologic examination. Digestive tract complaints were present in about 20% of examined cases. These complaints seemed to be related to emotional disturbances; all cases with organic complaints were accompanied by chest pain and bradycardia. Cases of this analysis. ECG abnormalities consisted in signs of an changes (liver diseases, ulcers, etc.) were excluded from incomplete block of the right His bundle and wee ac-organic heart lesions were excluded from this analysis.

DISCUSSION AND CONCLUSIONS

The incidence of functional disturbances in both examined groups is unusually high. It was demonstrated experimentally that MW exposure may induce various functional, metabolic, and even structural changes in the nervous system (see 7 and 4 for references). If MW exposure would be responsible for the functional disturbances observed in both groups, a relationship between the incidence of disturbances and exposure dose

(i.e. exposure levels) and/or duration of occupational exposure would be expected. The comparison between both groups, as well as the analysis of subgroups of various occupational exposure duration within groups, did not demonstrate any such relationship. It should be added that no such relationship was demonstrated, also, for the incidence of severe disturbances, considered contraindication for further occupational exposure (2). In view of this the question of the causal relationship between MW exposure and the functional disturbances observed should be left open. Further experimental and epidemiologic studies, particularly of MW workers exposed to other power density levels than those to which the personnel examined in this study was subjected, are needed.

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