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MATHEMATICAL ANALYSIS OF BIBLIOMETRICAL INDICES OF INVESTIGATON OF BIOLOGICAL ACTION OF NON-IONIZED RADIATION (MEDLINE-INTERNET)

Interest in biological effects of electromagnetic (EMF), magnetic (MF), and electrical (EF) fields has existed for many centuries and even thousand years. In the XX-th century Russian researches (including the author of the present work) made essential contribution to development of this problem. Historical aspects of electromagnetic biology are elucidated in a number of monographs [16, 17, 19, 20]. However in these scientific publications only single quantitative characteristics of publications on the indicated trend take place. Towards middle of the seventies years of XX-th century probably more 3 thousand publications on biological effects of EMF and about 2 thousand publications on biological effects of MF were accumulated [17]. 20 years later the number of publications concerned electromagnetic biology is believed to reach 10 thousand [7, 20].

Bibliometrical investigation of published material on electromagnetic biology was not carried out up to now. The present work is devoted just to this material. Preliminary results on this problem partly were presented in our another papers [7, 15].

Materials and methods

Information accumulated in world on electromagnetic biology during 35-year period in the later half of the XX century (1966-2000) was considered. The state of investigations of biological effects of EMF, MF and EF was carried out by means of the database "Medline" accessible in Internet. Moreover especially biological effects of microwaves (MW) were selected because this factor was in the center of attention of researchers in the middle of the XX-th century. Quantitative characteristics of publications on the present problem were obtained for every observed year according to key words

At statistical analysis of the material the coefficient of correlation

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and Wilcoxon paired comparison test are used. Besides the comparison of the parts of the numbers of publications carried out with different physical factors in general totality and the comparison of the numbers of publications in different time periods were performed as the comparison of two selective sampling fractions of variants.

Results and discursion

The number of papers with application of non-ionized radiation during 35-years period was 21606. General quantitative data on the numbers of investigations, carried out with employment of different kinds of non-ionized radiation, are presented in table 1. Mathematical comparison of the numbers of papers of indicated trends is demonstrated in table 2. Different kinds of dynamics of the quantity of papers carried out with non-ionized radiation during 35-year time interval are displayed in table 3.

Table 1

General data on the number of papers carried out with non-ionized radiation during 35-year period

Objects	Characteristics of totalities			
	Total number of papers in 35 years	Average number of papers in 1 year	Standard deviation	Sampling fraction (%)
1	6001	171.45	25.18	27.77
2	6920	197.71	17.57	32.03
3	5316	151.88	24.49	24.60
4	3369	96.25	12.97	15.59
5	21606	617.31	77.16	100.00

Application: 1 - electromagnetic fields, 2 - microwaves, 3 - magnetic fields, 4 - electrical fields, 5 - sum.

The table 1 performs what investigations of action of EMF and MW predominate. The least number takes place at papers whit EF.

The table 2 shows positive correlation between the numbers of papers made with different penetrating factor. However significant distinctions between analyzed consequences exist, which is revealed by means Wilcoxon paired comparison test and comparison of sampling fractions.

Table 2

Comparison of quantitative indices of papers carried out with different non-ionized radiation during 35-year period

Objects	Comparison of totalities		
	Coefficient of correlation	Wilcoxon paired comparison test (U)	Comparison of sampling fractions (U)
1 с 2	0.89	2.47	9.77
1 с 3	0.88	3.26	7.38
1 с 4	0.95	4.98	30.87
2 с 3	0.67	4.41	17.15
2 с 4	0.82	4.73	40.64
3 с 4	0.95	4.87	23.49

Application: 1 - electromagnetic fields, 2 - microwaves, 3 - magnetic fields, 4 - electrical fields. Significant values of coefficients of correlation and statistically significant distinctions between distributions and between sampling fractions are underlined (U>1.96 corresponds to p<0.05, U>2.58 corresponds to p<0.01).

Table 3

Dynamics of the quantity of papers carried out with non-ionized radiation during 35-year period

Objects	Indices for different five-years periods						
	1966-70	1971-75	1976-80	1981-85	1986-90	1991-95	1996-2000
The numbers of papers							
1	53	123	396	645	982	1675	2127
2	233	469	815	1053	1196	1603	1551
3	56	137	290	530	949	1345	2009
4	51	88	254	358	653	859	1104
5	393	817	1755	2586	3782	5482	6791
The sampling fractions (%)							
1	13.49	15.06	22.56	24.94	25.79	30.55	31.32
2	59.29	57.04	46.44	40.72	31.62	29.24	22.84
3	14.25	16.77	16.52	20.49	25.09	24.53	29.58
4	12.98	10.77	14.47	13.84	17.32	15.89	16.26
5	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Comparison of sampling fractions in first five years with data in following five-year periods (values U)							
1	-	0,78	4,27	5,45	6,04	8,01	8,42
2	-	0,63	4,64	6,91	10,14	11,80	14,69
3	-	1,12	1,09	3,03	5,17	4,98	7,23
4	-	1,10	0,77	0,43	2,26	1,47	1,79

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Application: 1 - electromagnetic fields, 2 - microwaves, 3 - magnetic fields, 4 - electrical fields, 5 - sum. Statistically significant between sampling fractions are underlined (U>1.96 corresponds to p<0.05, U>2.58 corresponds to p<0.01)

Table 3 shows the steady essential increase of the numbers of considered papers during 35-year time interval. The effect is statistically significant in majority of cases excepting investigations with EF. Nevertheless the part of publications on action of MW in general totality undergoes gradual decrease.

Performance of the present bibliometrical investigations shows that the number of papers on biological effects of non-ionized radiation is too big. It is undoubtedly, absolute numbers of investigations of the action of considered factors steadily increase. However dynamics of the sampling fractions (%) of publications on different factors are not identical. Dynamics of works with application of MW possesses specific character. The point is that intensity of investigation of any trend is determined by technical equipment of society.

The prevalence of study in sphere of applied aspects of the problem - dosimetrical, hygienic, therapeutic - took place [7, 15]. Fundamental investigations of effects of non-ionized radiation are little.

The nervous system plays a key role in the reactions of animals and humans to these penetrating factors. Our investigations are pioneering in the field of brain electrical processes, including events at the neuronal level, under different electromagnetic and magnetic irradiations. Among the physiological mechanisms of the microwave influence on the brain, the direct action on brain structures prevails [1-3, 18]. Unfortunately so far, little attention has been paid to fundamental researches of the functional state of the brain under non-ionized irradiation. In our previous investigations it was found for the first time that 1-min irradiation had a little effect on the mean frequency of cortical neuron activity but produced significant shifts in evoked activity [4, 6]. Our further works showed that non-ionized irradiation modified an inner pattern of pulse flows of neurons [7-14].

On the whole fundamental investigations of neurophysiological effects of non-ionized radiation are played no enough attention to. However, in the future they will hold a leading position in solution of the problem of biological action of these factors, since they will make it possible to uncover genesis and patterns of reactions of organism. In

addition, the greatest importance will belong to investigations on neuronal level [5].

Conclusion

Thus at present Internet makes it possible to carry out bibliometrical investigations, what did not exist formerly. The large number of papers on biological effects of non-ionized radiation is found. The special features of quantitative characteristics of publications on EMF, MW, MF, and EF are described. Complex dynamics of quantity of publications is described. The bibliometrical analysis by mean of Internet has brilliant future.

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