

**MATHEMATICAL ANALYSIS OF BIBLIOMETRICAL  
INDICES OF NEUROPHYSIOLOGICAL INVESTIGATIONS  
OF ACTION ELECTROMAGNETIC FIELDS (MEDLINE-  
INTERNET)**

**Introduction**

Biological effects of electromagnetic fields (EMF) interested humanity for many centuries. Development of modern society is connected to the extensive use of electromagnetic fields of wide frequency and intensity range. Sources of the electromagnetic radiation are radio communications, various radar systems, some technological processes at enterprises, transport, research instruments, wiring, home electric appliances, and etc. Technical progress promotes expansion of investigations of influence of EMP on organism [8]. It is known, that the nervous system is of great significance in different reactions of animals and humans to EMF [1, 2].

Towards middle of the seventies years of XXth century probably more 3 thousand publications on biological effects of EMF and about 2 thousand publications on biological effects of magnetic fields were accumulated [8]. 20 years later the number of publications concerned action of non-ionizing radiation of different kinds is believed to reach 10 thousand [2, 9]. Now they number is about 70 thousand [4, 7]. Nevertheless bibliometrical investigation of published material on electromagnetic biology including neurophysiological aspects was not carried out up to now. The present work is devoted just to examination of quantitative characteristics of publications of this trend, specifically on action of EMF upon neurophysiological objects.

Preliminary results on this problem partly were presented in our another papers [4, 71].

**Materials and methods**

Quantitative characteristics of publications on neurophysiological effects of EMF in world during 35-year period in the later half of the XX-th century (1966-2000) was considered. Investigations of this trend were analyzed on the base of the database "Medline" accessible through Internet. The numbers of publications on the present problem were ob-

tained according to chosen key words. Bibliometrical data concerned investigations performed with application of EMF in different neurophysiological objects (the brain, the cortex, neurons, nerves).

At statistical analysis of the material the comparison of sampling fractions of received data from them sum, from the total number of works with application of EMF, and from the total number of works carried out in corresponding neurophysiological objects are used. Calculations were performed on the base of  $t$ -criterion for selective portions of variants.

### Results

Information on quantitative characteristics of neurophysiological publications on effects of EMP was received on fundamental subdivision -the brain, the cortex, neurons, nerves. On the whole the number of published works carried out in different neurophysiological objects reached 1401300 in 35-years period. The numbers of investigations carried out in the brain, the cortex, neurons, nerves were 705259, 180602, 237160, 278279 correspondingly. The total number of works with application of EMF was 6001. Materials concerned investigations in different neurophysiological objects under action of EMF were considered.

Characteristics of received totalities is presented in table 1.

Table 1

General data on the number of published works carried out in different neurophysiological objects with application EMF during 35-year period

Objects	Characteristics of totalities			
	Total number of papers in 35 years	Sampling variance	Average number of papers in 1 year	Standard deviation
1	1112	1144.53	31.77	5.75
2	409	201.93	11.69	2.40
3	277	70.85	7.91	1.42
4	354	117.57	10.11	1.83
5	2152	4346.90	61.49	11.14

*Application: 1 - the brain, 2 - the cortex, 3 - neurons, 4 - nerves, 5- sum.*

Table 2

Sampling fractions of received data from them sum, from the total number of works with application of EMF and from the total number of works carried out in corresponding neurophysiological objects

Objects	Characteristics of totalities		
	Sampling fraction from these data (%)	Sampling fraction from total data with EMF (%)	Sampling fraction from total data in these objects (%)
1	51.67	18.53	0.16
2	19.01	6.82	0.23
3	12.87	4.62	0.12
4	16.45	5.90	0.13
5	100.00	35.86	0.15

*Application: as in table 1.*

Table 3

Comparison of sampling fractions of received data from them sum, from the total number of works with application of EMF and from the total number of works carried out in corresponding neurophysiological objects

Objects	Comparison of sampling fraction of totalities		
	Comparison of sampling fraction from these data ( $U$ )	Comparison of sampling fraction from total data with EMF ( $U$ )	Comparison of sampling fractions from total data in these objects ( $U$ )
1-2	<u>19.71</u>	<u>11.84</u>	<u>6.07</u>
1-3	<u>24.88</u>	<u>14.99</u>	<u>5.40</u>
1-4	<u>21.77</u>	<u>13.05</u>	<u>3.55</u>
2-3	<u>5.17</u>	<u>3.15</u>	<u>8.64</u>
2-4	<u>2.07</u>	1.21	<u>8.93</u>
3-4	<u>3.10</u>	1.94	1.07

*Application: significant values of coefficients of correlation and statistically significant distinctions between distributions are underlined ( $U > 1.96$  corresponds to  $p < 0.05$ ,  $U > 2.58$  corresponds to  $p < 0.01$ ); the other designations as in table 1.*

Sampling fractions of received data from them sum, from the total number of works with application of EMF and from the total number of works carried out in corresponding neurophysiological objects are shown in table 2. Statistical comparison of indicated sampling fractions is reflected in table 3. Dynamics of the number of published works carried out in different neurophysiological objects and dynamics of the considered sampling fractions are demonstrated in tables 4-7.

Table 4

Dynamics of the number of published works carried out in different neurophysiological objects with application EMF during 35-year period

Objects	Indices for different five-year periods						
	1966-70	1971-75	1976-80	1981-85	1986-90	1991-95	1996-2000
1	9	17	37	76	183	352	422
2	5	2	7	21	80	125	169
3	4	8	12	15	56	83	99
4	0	4	13	24	68	127	118
5	18	31	69	136	387	687	808

*Application: as in table 1.*

Table 5

Dynamics of the sampling fractions (%) of published works carried out in different neurophysiological objects during 35-year period from them number

Objects	Indices for different five-year periods						
	1966-70	1971-75	1976-80	1981-85	1986-90	1991-95	1996-2000
1	50.00	54.84	53.62	55.88	47.29	51.24	52.23
2	27.78	6.45	10.14	15.44	20.67	18.19	20.92
3	22.22	25.81	17.39	11.03	14.47	12.08	12.25
4	0	12.90	18.84	17.65	17.57	18.49	14.60
5	100	100	100	100	100	100	100

*Application: as in table 1.*

Table 1 demonstrated that investigations made on the whole brain with employment of EMF predominate. This phenomenon is the result of increased interest of specialists of applied sciences to investigation of effects of EMF in the whole brain.

As far as information performed in tables 2 and 3, firstly sampling fraction from total data in corresponding neurophysiological objects

with EMF prevails in works carried out in the whole brain. Secondly similar effect is at the total number of works with application EMF. These differences are statically significant. However increased sampling fraction from all works in neurophysiological objects takes place in investigations on the cortex. The reason of this fact is relatively small part of the number of investigation on the whole brain in general totality of neurophysiological works.

Table 6

Dynamics of the sampling fractions (%) of published works carried out in different neurophysiological objects during 35-year period from the total number of works with application of EMF

Objects	Indices for different five-years periods						
	1966-70	1971-75	1976-80	1981-85	1986-90	1991-95	1996-2000
1	16.98	13.82	9.34	11.78	19.02	21.01	19.84
2	9.43	1.63	1.77	3.26	8.32	7.46	7.94
3	7.55	6.50	3.03	2.33	5.82	4.96	4.65
4	0	3.25	3.28	3.72	7.07	7.58	5.55
5	33.96	25.20	17.42	21.09	40.23	41.01	37.99

*Application: as in table 1.*

Table 7

Dynamics of the sampling fractions (%) of published neurophysiological works with application of EMF during 35-year period from the total number of works carried out in corresponding neurophysiological objects

Objects	Indices for different five-year periods						
	1966-70	1971-75	1976-80	1981-85	1986-90	1991-95	1996-2000
1	0.02	0.03	0.05	0.08	0.15	0.25	0.27
2	0.04	0.01	0.03	0.09	0.28	0.35	0.42
3	0.05	0.06	0.06	0.05	0.13	0.14	0.15
4	0	0.02	0.04	0.06	0.14	0.22	0.19
5	0.02	0.03	0.05	0.07	0.24	0.23	0.25

*Application: as in table 1.*

Dynamics of the studied indices during 35-year period is presented in tables 4-7.

Steady, but non-linear, increase of the numbers of published works carried out in different neurophysiological objects with application took place during EMF 35-year period (table 4).

Dynamics of the sampling fractions (%) of published works carried out in different neurophysiological objects during 35-year period from them number did not possess essential increase (table 5). The reason of this fact is probably similar increase of all indices (table 4).

Dynamics of the sampling fractions (%) of published works carried out in different neurophysiological objects during 35-year period from the total number of works with application of EMF displayed non-linear fluctuations (table 6). It is curious that the sampling fractions of the works on neuronal level shown decrease.

Dynamics of the all sampling fractions (%) of published neurophysiological works with application of EMF during 35-year period from the total number of works carried out in corresponding neurophysiological objects had considerable increase (table 7).

### Conclusion

The present bibliometrical investigations permitted to consider of quantitative characteristics of published works carried out with application EMF in different neurophysiological objects during 35-year period. The whole brain, the cortex, neurons and nerves were selected for examination on this trend. Besides dynamics of the number of published works carried out in different neurophysiological objects and dynamics of the considered sampling fractions were studied.

Mathematical analysis showed that the least number is observed at works of effects of EMF on neuronal level. It is necessary to acknowledge that methodical complexities of investigations on neuronal level serves restrictive circumstance.

Dynamics of the number of investigated indices was non-linear and compound. Significant increase was found at the sampling fractions (%) of published neurophysiological works with application of EMF during 35-year period from the total number of works carried out in corresponding neurophysiological objects

Unfortunately fundamental investigations of neurophysiological effects of EMF are played no enough attention to. In particular this supposition concerns investigations on neuronal level. However, in the future they will hold a leading position in solution of the problem of biological action of EMF [1, 3, 5, 6]. Investigations supported by the Grant of Russian Foundation of Fundamental Investigations, 00-04-48139.

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