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Investigation of Influences of Environment Electromagnetic Field Irradiated by High-Voltage Transmission on the Health of Human and Animals

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Abstract

Objective: Influences of environment electromagnetic fields (EMF) irradiated by the high-voltage transmission lines(HVTL) on the health of human and animals including the brain, heart, and muscle electrical-informations as well as the memory function of brain in animals are investigated, measured, and inspected.

Methods: Epidemiological investigations of hearth cases of 1400 people inhabiting near high-voltage transmission line in Sichuan, Beijing, Hunan, and Jiangxi, etc. and measurements of variation of physiological features of people, who live in domain of high-voltage transmission and around transformer substations relative to those far away from high-voltage transmission systems. The changes of brain, heart, and muscle electrical-informations as well as the memory function of brain are inspected by EGI SYSTEM 200 brain electrical information instrument with 250 channels and multi-channel physiological signal acquisition processing system, respectively.

Results: The strengths of electromagnetic field irradiated by the high-voltage transmission lines are depressed with decreasing their height from 7000 V/m and 0.1 G to 300 V/m 0.01 G. The environment electromagnetic fields can result in the memory loss, distracted, high increase in blood fat, significantly increases of chronic diarrhea, anemia, and incidence of hoarseness symptoms, but it can also depress the incidence of leukopenia and thrombocytopenia symptoms. Its influences on the hearth of women are smaller than those of men. Otherwise, the results of measurements of brain, heart, and muscle electrical-informations indicate that EMF of HVTL can change the properties of the images of the brain, heart, and muscle electrical-information of the animals in different degrees.

Conclusion: EMF irradiated by HVTL can influence the hearth of human body as well as the brain, heart, and muscle electrical-informations of animals at different degree.

***Keywords:** High-voltage transmission; Electromagnetic field; Irradiation; Health of human body; Epidemiological survey; Rats; Brain; Heart and muscle electrical informations; Property; Variation*

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Introduction

As it is known, we now live in the electromagnetic environment, and our living environment is the space replenished by the electromagnetic field or waves with different frequencies and strengths, which are generated by the irradiations of the high-voltage transmission lines, different electrical appliances, microwave stations and radio equipments, and so on. With the development of the industry and agriculture, science and medicine the high voltage transmission lines, television, radio, devices, and instruments with electromagnetic and microwave radiation are extensively distributed and filled in our life space, they can irradiate a great number of environment electromagnetic fields or waves with different strengths and frequencies at present. Therefore, it is very correct that we now live really in the electromagnetic environment, or speaking each man and woman are all interacted with the environment electromagnetic fields or waves with different strengths and frequencies, only distinctions for each man and woman are that the strength and frequencies and times accepted the electromagnetic waves are different, or speaking, there are not the men and women without action of electromagnetic wave in present world. In this case it is quite necessary and more urgent to know whether these environment electromagnetic fields or waves can influence and damage the health of men and women. This means that it is also quite necessary and more urgent to study the really biological effect of these environment electromagnetic fields (EMF) and waves (EMW). In practice, this problem was already investigated about 50 years by plenty of men and women and a great number of articles and papers were already published [1-24]. For example, Li et al. [10-15] studied the influences of electromagnetic irradiation of high-voltage transmission lines (HVTL) on cell proliferation, features of blood and its rheology properties and the electromagnetic properties of biological tissue as well as molecular structure of myoglobin in rats and mice. Zhang et al. [16-18] researched the expressions of matrix metalloproteinases and tight junction proteins and the changes of the fluorescence spectrum of serum in rats arising from the electromagnetic irradiation, Pang XF et al. [18] studied influence of electromagnetic irradiation of HVTL on the rats. Celik et al. [25,26] studied the influences of high voltage transmission line on hearth of the humans, Sert et al. [26] investigated the efforts of life-body chronic 50 Hz sinusoidal weak magnetic field exposure on the rat pituitary hormones, Dasdag et al. [27] discussed the logical effect influences of microwaves and extremely low frequency (ELF) magnetic fields on the phagocytic activity of variously treated rat macrophages. Akdag et al. [28] debated the long-term effects of extremely low frequency (50 Hz) magnetic field affect apoptosis, reproduction, and oxidative stress, and so on. At the same time, the epidemiological investigations show that the EMW and EMF including the EMF of HVTL are always harmful to the health of animals, men and women [3-15]. However, a correct and successful conclusion for this problem have not been obtained up to now. This exhibits the difficulty to investigate the exact influence of the electromagnetic field (EMF) or wave (EMW), such as EMF irradiated by the high-voltage transmission lines (HVTL), on the health of men and women. The reasons resulting in this state are that the correct and credible experimental methods and results have not been used and obtained on the one hand, the mechanism of influence of electromagnetic field on the life activity has not revealed yet on the other hand [1,2]. With the great increases and wide uses for the electrical appliances and instruments in industry, agriculture, medicine, and everyday life, which used all EMF or electric-currents of HVTL, in both the density of distribution and the length of transmission lines, which result in great increases of the strength and areas of electromagnetic irradiation, in our live environments, it is now very necessary and more urgent to study the biological effect of electromagnetic field of HVTL. This implies that we must investigate completely and in-depth the mechanism of biological effect of electromagnetic field of HVTL and their properties using some new ideas and new methods, which can explain and demonstrate really and directly the biological effects of EMF of HVTL and its influences on the health of men and women.

In this paper, we will research the biological effects of electromagnetic field irradiated by HVTL with 50 Hz and its influences on the health of men and women using the method of epidemiological survey and direct measurement of physiological features. At the same time, we here will also research the influences of electromagnetic irradiation of HVTL with 50 Hz on the on the properties of brain, heart, and muscle electrical informations in animals using some special method. The main features of the studied method are that the times exposed in the electromagnetic field irradiated by HVTL for the animals is very longer, which is about 400 days, instead of 20 days or 30 days. This is based on the properties of bio-tissues and electromagnetic irradiations of HVTL as well as their interactions. Why? As it is known that the actions of electromagnetic irradiations of HVTL of lower frequencies with bio-tissues or life-bodies have a domain, instead of a point on the one hand, the bio-tissues possess all the mechanical feature of elasticity and biological properties of self-renovation and self-assembly, self-replication, and self-modulation on the other hand. These properties destine or determine that the time of irradiations of HVTL must be quite long, or else it has not the effect or its effects are unstable or undetermined because the changed properties of bio-tissues under action of EMF are easily can be restored to original states, if the exposed times are short, especially for the macroscopic biological effects, such as the properties of brain, heart, and muscle electrical informations. Therefore, we here emphasize the importance of long time exposure of the animals. Thus, we can affirm that the biological effects of EMF of HVTL obtained by this method are credible and reliable.

Methods of Epidemiological Survey and Measurement As Well As Measured Instruments

We first formulate and establish the rules of the epidemiological survey for influence of health of EMF of HVTL on men and women which are described as follows [1-2].

1. We do the epidemiological survey and collect related informations in the places and domain of dense distribution of HVTL. Thus, we chose the domains of Sichuan, Hunan, Jiangxi and Guizhou provinces, Beijing city and Three Gorges region, which are the domains using a great number of electric-powers in China.
2. The people taking part in the epidemiological survey should contain both men and women on the one hand, as well as the elderly, adults young on the other hand.
3. The crowd or people taking part in the epidemiological survey should be chosen randomly in the above domains.
4. The contents of the epidemiological survey should include the features and properties related to biology and physiology in the nervous system, blood circulation system, cardiovascular system, and reproductive system.
5. For comparison, the peoples in the epidemiological survey are separated as two groups, experimental group, in which the peoples live and exposed in the EMF irradiated by HVTL about 3-4 years, and controlled group, in which the peoples live in the domain distance about 100 m with the region of EMF irradiated by HVTL in the same places, where each group contains 15 persons.
6. At the same time, the peoples taking part in the epidemiological survey in the experimental group should be large than 1000.
7. Our investigation here contains two parts, one is practical epidemiological survey, other is the measurements of physiological features of the peoples in the experimental and controlled groups involving the brain, heart, and muscle electric informations as well as blood routine index.

In this investigation, EGI SYSTEM 200 brain electrical information instrument with 250 channels made by USA and multi-channel physiological signal acquisition processing system made Chengdu instrument Co. are used to inspect and measure

the brain, heart, and muscle electric informations of peoples. 670 Nicolet FT-IR spectrometers with a resolution of 4 cm^{-1} made by Nicolet, USA is used to the infrared spectra of the bio-tissues.

In our experiments, 20 Wistar albino rats with the proliferated periods of six month are again bred about 4 weeks for adapting environment and foods in our experimental laboratory. At 4^{th} week they are divided into two groups, the controlled and experimental groups. The experimental group is exposed in electromagnetic field irradiating by HVTL with 220 kV and 50 Hz about 400 days at 27°C, the experimental device of the electric field of HVTL is shown in FIG.1, its experimental device of magnetic field is shown in FIG. 2. FIG. 1 is, in essence, a condenser of parallel plate; the two ends of HVTL are linked on the two plates of the condenser. This device guarantees that the strengths of electric field, which are acted to the rats in plastic box of cultivation, are uniform and same. FIG. 2, in essence, a solenoid, which can guarantee the strengths of magnetic field, which are acted to the rats in plastic box of cultivation, are uniform and same.

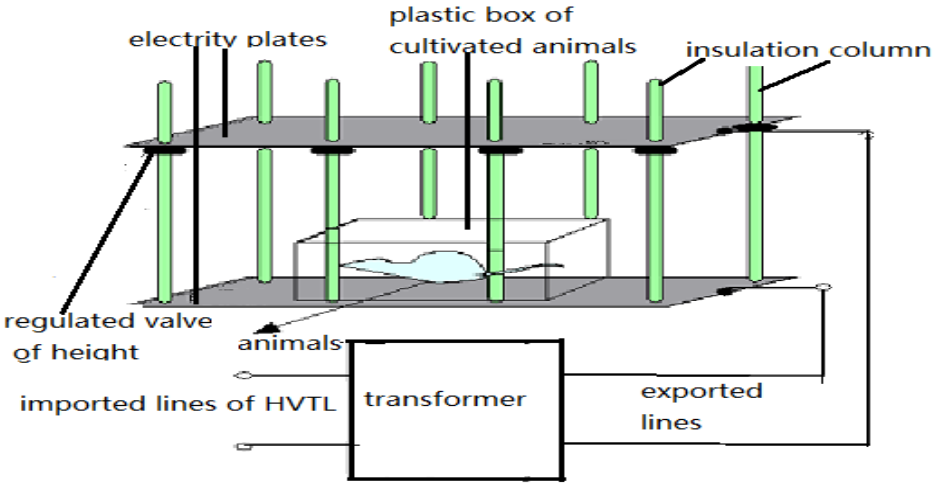

FIG. 1. **The exposed device of the electric field irradiated by HVTL in the animal experiment.**

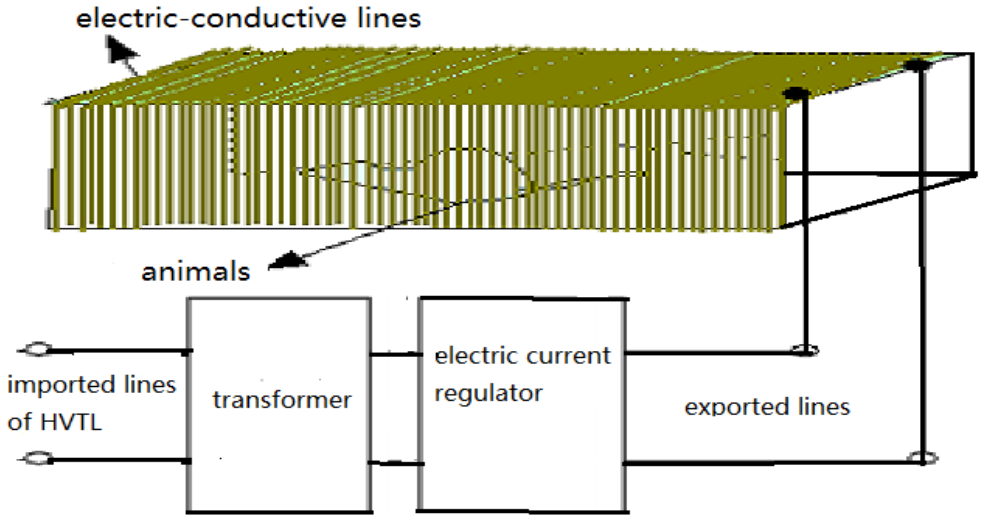

FIG. 2. **The exposed device of the magnetic field irradiated by HVTL in the animal experiment.**

The strength of electric field is about 4000 V/m, the strengths of magnetic field is about 0.09 G-0.1 G. These data were accurately and more times measured and obtained by us in Beijing and Chengdu, respectively. The strengths of electric and magnetic fields are just those of the electric and magnetic fields irradiated by HVTL with 220 KV at the position of 1.8 m-2.3 m distancing the earth plane in surrounding of HVTL with 220 KV, that are the average height of persons on the earth. In this experiment, these rats were exposed about 16 h each day in these devices, where the above electric and magnetic fields are generated by HVTL with 220 KV through the transformer. The controlled group is placed in the same laboratory with same environment condition, which but has the distant with the experimental group about 7 m.

The Experimental Results

The results of epidemiological survey for the influences of EMF of HVTL on the health of people

The measurement of distribution of e EMF irradiated by HVTL: We have measured in detail the distribution of the electric voltage as well as the electric and magnetic strengths in EMF irradiated by HVTL with 220 KV and 110 KV and 50 Hz around the ground by the voltage instrument or multimeter and magnetometer, respectively, where the HVTL has the distance of about 12 m-15 m from the surface of the earth. We obtained the strengths of electric-field and magnetic-field in EMF of irradiated by HVTL are changed from 300 VF/m to 7000 V/m and from 0.01 G to 0.1 G, when the distances are varied from om-2.3 m relative the surface of the earth. Thus, we used often the strengths of electric fields of 5000 V/m-6000 V/m and magnetic-field of 0.08 G-0.1 G, which are acted on the persons with the heights of 1.6 m-2.3 m, respectively.

The results of epidemiological survey for the influences of EMF of HVTL on the health of people: We collected 2164 tables of epidemiological survey from the domains of Sichuan, Hunan, Jiangxi and Guizhou provinces, Beijing city and Three Gorges region, which contain the informations related to the features and properties related to biology and physiology in the nervous system, blood circulation system, cardiovascular system. Their values are shown in TABLE 1. From these results, we know that the EMF irradiated by HVTL affect and interference the states and features of the nervous system, skin and subsidiary organs, the organs of eye, ear, nose, and throat. In these organs, the falling ill rate of the nervous system is most high and can reach 64.7%, i.e., the number of people falling nerve ill can reach 64.7%, if the number of people investigated is 100. The nerve ill arising from EMF irradiated by HVTL includes the dizziness, headache, dizziness, drowsiness, fatigue, insomnia, difficulty sleeping, much dream, be agitated, angry, forgetfulness, memory loss, and inattention, in which the falling ill rate of the memory decline can reach 20.5%. At the same time, the falling ill rate of skin and affiliated organs is 19.2%, in which appeared diseases have often the itching and hair loss, where the falling ill rate of hair loss reaches 10.1%. The falling ill rate of blood circulatory system reaches 17.1%, in that the heart palpitations and hypertension diseases are main, the latter accounted for 7.15%. In the digestive system, the diseases of anorexia and constipation are higher, where the constipation disease can reach 9.78%. In the urogenital system, the falling ill rate of frequency of urine discharge and sexual dysfunction are higher, the latter reaches 2.86%. In the blood circulation system, the diseases of anemia and hyperlipidemia is more apparent, where the falling ill rate of anemia is 14.62%. Many sweat is significant in the endocrine system disease, it accounted for 13.95%. Vision loss and burst into tears in the eye and ear disease, the tinnitus is obvious, but the vision loss by up to 19.65%.

On the other hand, we classified and have done the statistics and comparisons of the above data for the peoples of different types, different genders, different age groups and found further that the differences of disease symptoms and ratios among the

different blood types are not obvious. The comparison of percentage for the falling ill of peoples with different blood type under affection of EMF of HVTL is shown in FIG. 3. The differences of sickness status and ratios between male and female are also small. However, with the increasing of the age, the falling ill rates are also increased. The comparison of percentage for the falling ill of men arising from EMF of HVTL in the experimental group with that in controlled group is shown in FIG. 4.

TABLE 1. **The comparison of the percentage of falling ill rates of men between the experimental and controlled groups in the results of epidemiological survey.**

	cancer	1~1	1~2	1~3	1~4	1~5	1~6	1~7	1~8	1~9	1~10	1~11	1~12	1~13	1~14	1~15	1~16
s-male	0.6	10.4	10.7	12.1	14.1	11.8	13.4	13.1	10.4	9.97	1.79	4.61	10.7	4.76	6.99	5.21	13.54
d-male	1.47	7.14	10.9	9.66	8.19	7.98	11.6	7.14	12.2	8.19	3.99	5.25	8.4	4.41	5.04	4.2	9.66
	1~17	1~18	1~19	1~20	1~21	2~1	2~2	2~3	2~4	2~5	2~6	2~7	2~8	3~1	3~2	3~3	3~4
s-male	20.5	15.2	7.14	4.91	7.59	0.74	1.79	0.74	1.34	0.89	0.45	5.36	11	4.46	3.72	8.04	2.38
d-male	15.6	14.5	3.57	4.2	5.46	2.1	1.26	0.84	1.47	0.42	0	1.47	3.15	4.62	2.1	8.19	2.73
	4~1	4~2	4~3	4~4	4~5	4~6	4~7	4~8	4~9	5~1	5~2	5~3	5~4	5~5	5~6	5~7	5~8
s-male	11.2	2.98	4.61	3.57	1.04	0.89	0.89	0.45	0.74	3.87	1.79	1.04	0.89	0.45	0.74	0	2.38
d-male	13	2.52	4.62	1.05	0.63	0.63	0.21	0.42	0.01	5.67	1.89	0.63	0.63	1.05	1.05	0.42	3.36
	6~1	6~2	6~3	6~4	6~5	6~6	6~7	7~1	7~2	7~3	8~1	8~2	8~3	8~4	8~5	8~6	8~7
s-male	14.1	0.89	1.49	0.6	0.45	3.72	1.34	0.74	0.15	17.4	1.79	6.1	21	7.74	3.13	4.91	5.06
d-male	7.98	1.05	2.94	1.68	0.84	0.63	0.42	1.89	0.01	11.6	3.36	6.93	16	5.67	3.15	10.29	2.52

*where, s-male denotes the men in experimental group, d-male denotes the men in controlled group, but 1~1: Vertigo; 1~2: Headache; 1~3: Dizziness, drowsiness; 1~4: Sleepy; 1~5: Lack of power; 1~6:Insomnia; 1~7: Trouble falling asleep; 1~8: More than dream; 1~9: Be agitated; 1~10: Panic; 1~11: Nervous; 1~12: Easy to anger; 1~13: Depression; 1~14: Anxiety; 1~15: Paranoid; 1~16: Forgetful; 1~17: Memory decline; 18: Inattention; 1~19: Distracted; 1~20: Moody; 1~21: Unseat or uncertainty of sit and lying;

2~1: Erythema; 2~2: Papules; 2~3: Wind group; 2~4: Blisters; 2~5: Pustules; 2~6: Purpura; 2~7: P itching; 2~8: Hair loss;

3~1: Palpitations; 3~2: Arrhythmia; 3~3: Hypertension; 3~4: Coronary heart disease (CHD);

4~1: Anorexia; 4~2: Nausea, vomiting; 4~3: Constipation; 4~4: Chronic diarrhea; 4~5: Chronic abdominal pain; 4~6: Jaundice; 4~7: Hepatomegaly; 4~8: Splenomegaly; 4~9: Cholecystitis;

5~1: High frequency of urine discharge, 5~2: Dysuria, 5~3: Urinary incontinence, 5~4: Enuresis, 5~5: Hematuria; 5~6: Male sterility; 5~7: Female sterility; 5~8: Hypogonadism bleeding tendency;

6~1: Anemia; 6~2: Bleeding tendency; 6~3: Thrombocytopenia; 6~4: Leukocytopenia; 6~5: Lymph node enlargement; 6~6: Hyperlipidemia; 6~7: High blood viscosity;

7~1: Goiter; 7~2: Breast lumps; 7~3: More Khans;

8~1: Conjunctivitis; 8~2: Tears, 8~3: Decreased visual acuity; 8~4: Tinnitus; 8~5: Sore throat; 8~6: Pharyngeal foreign body sensation; 8~7: Sound hoarse.

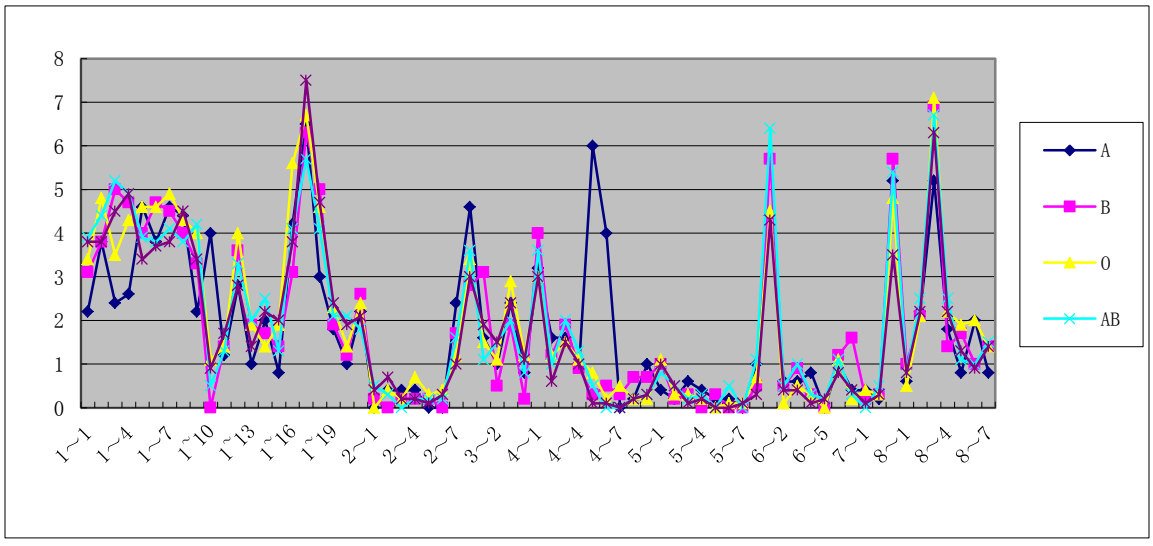

FIG. 3. **The comparison of percentage for the falling ill of peoples with different blood type under affection of EMF of HVTL, where A, B, O and AB denote the blood types of different persons, the meanings of another symbols in this figure are the same with those in TABLE 1.**

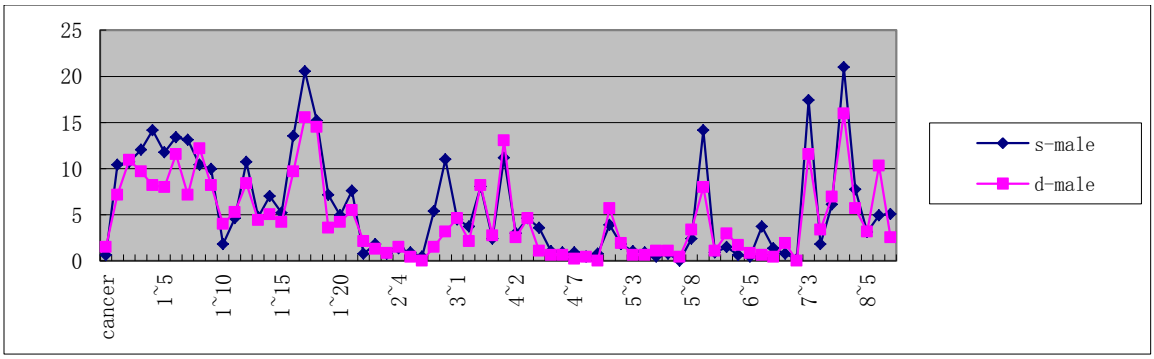

FIG. 4. **The comparison of percentage for the falling ill of men arising from EMF of HVTL in the experimental group with that in controlled group, where s-male and d-male denote the values of experimental and controlled groups, respectively, the meanings of another symbols in this figure are the same with those in TABLE 1.**

The results of measurements of brain, health and muscle electric information of peoples living the EMF irradiated by HVTL and their comparison with those in controlled group

The variations of brain-electric information under affection of EMF of HVTL: We used EGI SYSTEM 200 brain electrical information instrument with 250 channels made by USA to measure the brain-electric information of men and women in the experimental group, in which the peoples live in the transformer substation by HVTL, and controlled group, in which the peoples live not in transformer substation of HVTL, which are distances of 100 m with the irradiated domains, in accordance with the operated rules of this instrument. Their result obtained is shown in FIG. 5, which are the average values of 13 persons, where PSD expresses the power spectrum of brain-electric information. We measured mainly brain electric waves in α wave section（8~13 Hand θ wave section（1~3.5 Hz). FIG. 3 exhibits the variation of α and θ wave sections in the experimental and controlled groups, which represented clearly that the amplitude or strengths of α and θ wave sections in the experimental group are larger than those in the controlled group [1,2,10,29,30].

As it is known that when the persons are in the states of sober, quiet, and close their eyes, the α wave section occurs obviously. If its amplitude is increased, then the excitement of the brain is also increased. θ wave is related to the states of brain. If the brain is in the states of the sleep, depth of anesthesia, anoxia, and brain organic disease, then the amplitude of θ wave is very high. Therefore, the results in FIG. 3 manifest EMF irradiated by HVTL caused really the variations of brain electric information of peoples, thus the activity of biology of the brain is changed in this case, although we cannot affirm whether some diseases could appear. However, it is worth to study further [1,2,10,29,30].

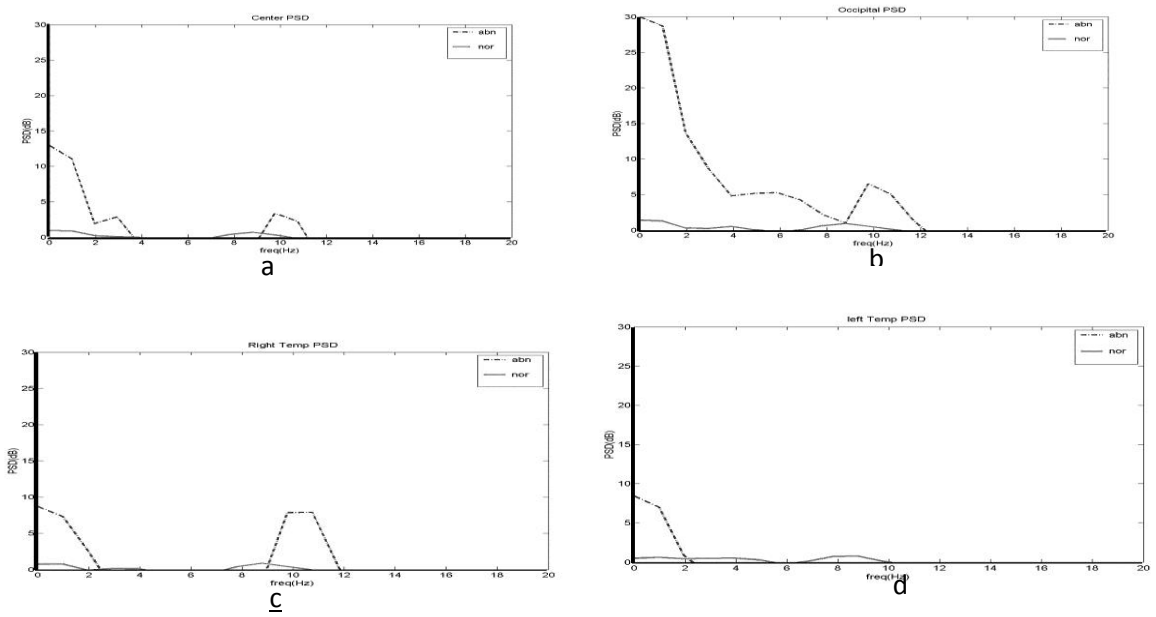

FIG. 5. **The spectra of brain electric informations of peoples in the experimental and controlled groups, where FIG. a denotes Center PSD: the parietal lobe brain PSD, FIG. b denotes Occipital PSD: Brain occipital lobe PSD; FIG. c denotes the left Temp PSD: Brain left temporal lobe PSD; FIG. d denotes the right Temp PSD: Brain right temporal lobe. In the meanwhile, "—abn" denotes the result of people living near a transformer substation in the experimental group; "—Nor" denotes the results of normal peoples in the controlled group.**

EMF irradiated by HVTL on heart-electric information: We used the multi-channel physiological signal acquisition processing system made Chengdu instrument Co to measure the hearth-electric informations of peoples in the experimental and controlled groups in accordance with the operated rules of this instrument. The results indicated that 23.1% persons are abnormal, and 7.7% persons have the margin effects in heart electrocardiogram in the experimental group. However, 20% persons are only abnormal and 10% persons have the margin effects in heart electrocardiogram in the controlled group. If to use the normal statistical methods of the disease we found that the rate appeared the abnormal electrocardiogram (ECG) for the residents, which live in the environment irradiated by HVTL and around the transformer substation, are great than those in other fields, which have not been irradiated by HVTL or around the transformer substation.

EMF irradiated by HVTL on the muscle-electric information: We used also the multi-channel physiological signal acquisition processing system made Chengdu instrument Co. to measure the muscle electrical informations of the residents in the experimental and controlled groups. If Using the statistical average method to analyze the zone time, maximum value, peak and its difference between the two points in the electromyography in the experimental and controlled groups we found that these values in the experimental group are different from those in controlled group, the former are significantly higher than the latter ($P<0.05$), for the average value of muscle electric voltage, the former is also significantly great then the letter($P<0.01$). These results are shown in TABLE 2.

TABLE 2. **The influences of EMF of HVTL on muscle electrical information in rats.**

	Old (year)	Zone time (s)	minimum (μV)	maximum (μV)	Peak value (μV)	Average value (μV)	Difference (μV)
CG	59.10 ± 12.50	1.4445 ± 0.5259	-36.8981 ± 17.6110	38.5752 ± 19.9169	77.4745 ± 37.1169	0.7898 ± 2.1359	-0.0550 ± 1.8275
EG	62.20 ± 9.48	1.6803 ± 0.5003	-22.1643 ± 8.0115	30.85.1 ± 9.8608	53.5383 ± 16.4990	4.0804 ± 0.3615	-0.7741 ± 1.7890
P value	0.540	0.295	0.017	0.250	0.080	0.001	0.364

*where “EG” denotes the experimental group, “CG” denotes the controlled group.

The Influence id EMF irradiated by HVTL on the routine blood indicators: LQ-300 K automatic biochemistry analyzer made by Epson company was used to inspect the routine blood indicators of peoples in the experimental and controlled groups. The results manifest that 23.1% persons in the experimental group are abnormal in the routine blood indicators, but, the routine blood indicators of 20% persons are only abnormal in the controlled group. The abnormal features involve the inversion of blood phase, the counts of red blood cell and hemoglobin are simultaneously and obvious lower relative to those of normal peoples, but these abnormal changes of peoples in the controlled group are smaller than those in the experimental group, although their white blood cell counts are also decreased, which but are higher than that in the experimental group. Obviously, this is due to the influences of EMF irradiated by HVTL or of transformer substation [1,2,10,29,30].

The influences of EMF irradiated by HVTL on the health of animals

The measurement of influences of EMF irradiated by HVTL on brain electrical information in rats: After 10 rats in the experimental group were fed 400 days they and 10 rats in controlled group are anaesthetized from the abdominal cavity using 2.5% urethane (1000 mg/Kg). Subsequently, we used EGI SYSTEM 200 brain electrical information instrument with 250 channels to measure the brain electrical information, in which these needle electrodes are inserted into the ear part (ground line), the midpoint between the two eyes, which corresponds to the frontal lobe in the brain, and two ears and the midpoint between the two ears, which corresponds to the he parietal lobe in the brain, respectively to inspect and record the states and forms of the electroencephalogram (EEG) in brain electrical information in rats. In the meanwhile, based on these results we can calculate the relative percentage (P value) of different wave sections of certain frequencies in total images of electroencephalogram (EEG) for the brain [29-30]. At the same time, we extracted the frontal lobe from brain tissues peeled open and fixed further it by 10% cold formaldehyde about 24 h, which is again washed by water and takes the dehydration using the alcohol and embed further by the paraffin. Finally, they are cut off as some slices with the thickness of 7 μm using the MICROM paraffin cut machine, which are again attached with the ZnSe slides. Thus, we can measure the powers of the electric waves of these tissues in the experimental and controlled groups using the instrument with 10 μm little spot. The

results of influences of EMF of HVTL on the brain electrical information in rat obtained using the EGI SYSTEM 200 brain electrical information instrument using the electromagnetic wave of the frequency of 1500 cm^{-1}-4000 cm^{-1} (or wavelengths of 6.67 μm -2.5 μm) are shown in TABLE 3, in which we gave the powers of transmission spectra of the frontal cells in the brain in rats in the experimental and controlled groups, which are the average value of 10 rats and where δ, θ, α, β denote the different wave sections appeared in the brain electrical images of the rats. Obviously, their values between the experimental and controlled groups as well as total powers are all different, but their P values are all in P>0.05. This implies that EMF of HVTL can affect the features of EEG, but their changes are not quite obvious because of P>0.05.

TABLE 3. **The influences of EMF of HVTL on the brain electrical information of rats in the experimental group (EG) and controlled group (CG).**

	Total power	**Power allocation** （%）			
		δ	**θ**	**α**	**β**
CG	6413.210 ± 809.059	68.7280 ± 10.0484	23.0950 ± 1.9684	6.7080 ± 1.0472	1.4673 ± 1.1729
EG	5590.230 ± 827.357	66.0579 ± 15.1224	24.6150 ± 1.7998	6.8380 ± 2.7043	2.3900 ± 2.0754
P value	0.486	0.411	0.434	0.919	0.159

As it is known that the brain function spectrum analysis notices mainly its power and frequency because they can reflect and denote the states and features of the brain. Its power spectrum contains the total power of various waves in the brain and power of basic frequency. The allocation of the powers of various wave sections are determined by their percentages in the total power in EEG. In general case θ and δ wave sections are basic and main in EEG in normal rats, but the main peak of power peak is in δ wave section, which are verified in TABLE 1, which represented that EMF of HVTL can influence the brain electric information, but this influence is small.

This conclusion can be confirmed by the infrared spectrum of brain tissues [31-35], which is shown in FIG. 6 obtained by 670 Nicolet FT-IR spectrometers with a resolution of 4 cm^{-1} for the experimental and controlled groups, which are the average values of 10 rats in 1500 cm^{-1}-4000 cm^{-1}. FIG. 3 indicates that there are all the absorbed peaks of 2964.44 cm^{-1}, 2931.22^{-1} and 2855.73 cm^{-1} in the experimental and controlled groups, but the peak of 2345.40 cm^{-1} occurs only in the experimental group, not in the controlled group. This means that the EMF of HVTL results in the alternation of vibrational feature of molecules and molecular structure of brain tissues [31-35]. This manifested clearly that the EMF of HVTL varied the feature and states of molecules, such as protein molecules, in the brain tissues. Therefore, we can affirm that the EMF irradiated by HVTL can influence the properties of brain electric information of rats.

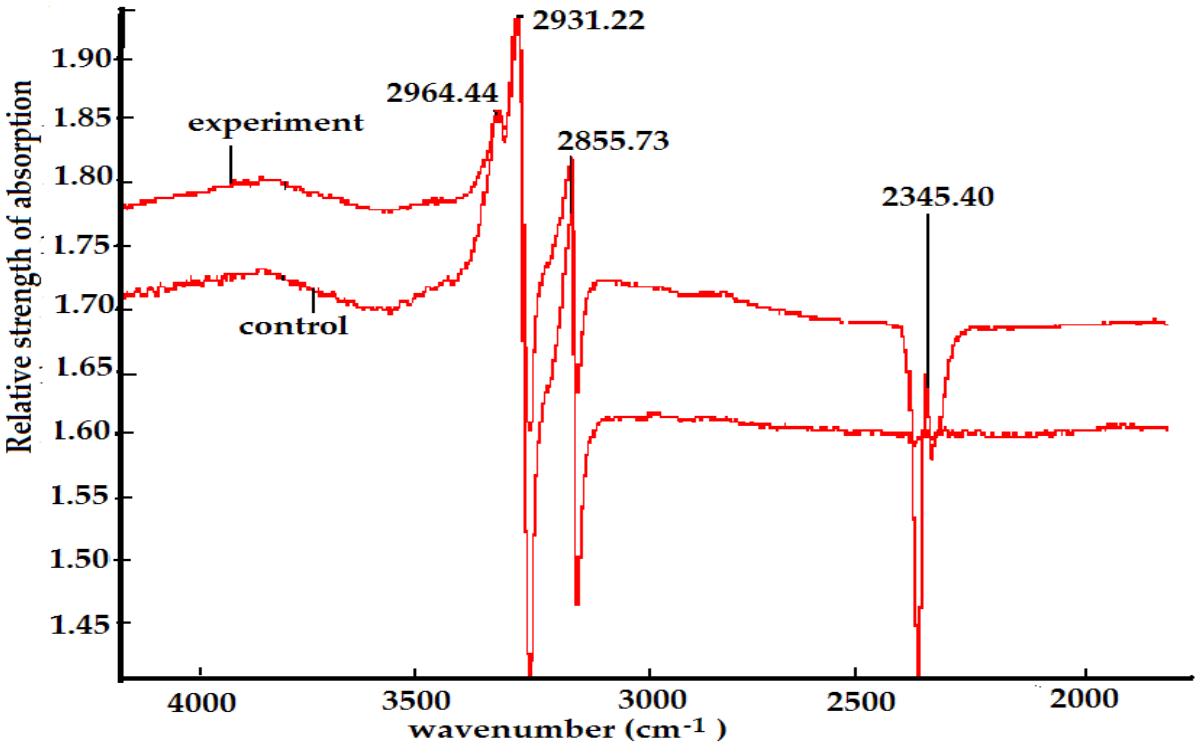

FIG. 6. **The infrared spectrum of the brain tissue.**

The measurement of influences of EMF irradiated by HVTL on the muscle electric information of rats: After 10 rats in the experimental group were fed 400 days they and 10 rats in controlled group are anaesthetized from the abdominal cavity using 2.5% urethane (1000 mg/Kg) and the prone form of their positions are fixed. Subsequently, we use multi-channel physiological signal acquisition processing system to inspect the influences of EMF of HVTL on muscle electrical information in rats, in which the bilateral sciatic nerve having 2 cm from 0.5 cm ~ 0.8 cm under the obturator to 0.5 cm-0.8 cm above knee is first exposed clearly through crosscutting mouth, which is long of 5 cm-6 cm at the line of hip shares of the rats. In this case the sciatic nerve is stimulated by the bipolar electrodes using square pulse wave of 0.2 S, and voltage of 0.8 mV and record the incubation period and amplitude size of the compound muscle action potential(CMAP). Finally, we calculate their average values of 10 rats, their result is shown in FIG. 6.

TABLE 4 showed clearly that the incubation period and amplitude size of CMAP in the experimental group are different evidently from those in controlled group, their distinction is significant because of $P<0.05$, in which the amplitude of wave of CMAP is depressed relative to that in the controlled group under action of EMF of HVTL. This indicates that EMF of HVTL varied the features of muscle electric information of rats.

TABLE 4. **The influences of EMF of HVTL on muscle electrical information in rats.**

	incubation period of CMAP（ms）（$\overline{X}$ ± S）		**Amplitude of wave of CMAP（mV）（$\overline{X}$ ± S）**	
	CG	**EG**	**CG**	**EG**
	1.2133 ± 0.1560	1.2600 ± 0.1069	6.2554 ± 0.5469	4.2108 ± 0.6577
P value	0.389		0.025	
*where “EG” denotes the experimental group, “CG” denotes the controlled group.				

The measurement of influences of EMF irradiated by HVTL on heart electric information of rats: When 10 rats in the experimental group were fed 400 days they and another 10 rats in controlled group are anaesthetized from the abdominal cavity using 2.5% urethane (1000 mg/Kg). After 3 min or 5 min we use the multi-channel physiological signal acquisition processing system to inspect the influences of EMF of HVTL on the heart electrical information in rats, in which the red electrode is inserted into the right upper limb in the limbs, the black electrode is inserted into the right lower limb and the green electrode is inserted into the left lower limb to measure and record the properties of the heart electric information of the heart tissue[30,31,36,37], in which we inspect the ratio of the heart, the amplitude of various wave sections and between each wave amplitude and the interphase periods among these waves as well as other parameters.

The measures are repeated about 5 times. The results obtained are shown in TABLE 4, which are some average values of measurement of 5 times for 10 rats, respectively. The data obtained are represented by $\overline{x}$ ± s, the average values of the electrocardiogram (ECG) are expressed using t test statistical analysis. The various indexes of ECG for the rats in the experimental and controlled groups obtained by us are shown TABLE 5, in which we gave the values of QRS schedule, peak value of QRS, T wave schedule, peak value of T wave, QT schedule, ratio of heart beating, period of motion of the heart, PR period, the schedule and peak value of P wave of rats in the experimental and controlled groups.

The TABLE 4 exhibit clearly that the period of motion of the heart is evidently extended ($p<0.01$), the ratio of heart beating is greatly shorted ($p<0.01$), the peak of T wave is greatly increased ($p<0.05$), the schedule of T wave is obviously extended ($p<0.05$), the schedule of P wave is obviously extended ($p<0.05$), but the changes of schedules and peak value of QRS are small ($p>0.05$), QRS peak little change ($p>0.05$), the variations of period of QT and PR as well as peak values of P wave are also small ($p>0.05$). These results exhibited clearly the EMF irradiated by HVTL change the features and states of the heart electric information of rats, thus the EMF irradiated by HVTL has an obvious biological effect [36,37].

TABLE 5. **The influences of EMF of HVTL on the heart electrical information in rats *where "EG" denotes the experimental group, "CG" denotes the controlled group.**

	Schedule of QRS (S)	**Peak value of QRS (mV)**	**T wave schedule (S）**	**Peak value of T wave （mV）**	**QT schedule (S)**
CG	0.0170 ± 0.0012	404.7750 ± 44.5452	0.0698 ± 0.0043	78.0250 ± 8.5365	0.0964 ± 0.0059
EG	0.0167 ± 0.0013	333.7143 ± 51.4327	0.0848 ± 0.0038	142.4286 ± 44.8844	0.1096 ± 0.0028
P value	0.877	0.333	0.023	0.028	0.077
	Ratio of heart beating (time/min)	**period of motion of the heart(S)**	**PR period(S)**	**Schedule of P wave(S)**	**peak value of P wave (mV)**
CG	462.4938 ± 26.3572	0.1330 ± 0.0084	0.0583 ± 0.0025	0.0121 ± 0.0012	49.8750 ± 13.3601
EG	275.0457 ± 30.3079	0.2393 ± 0.0342	0.0618 ± 0.0055	0.0202 ± 0.0020	50.2857 ± 10.5508
P value	0.001	0.007	0.552	0.04	0.982

The measurement of influences of EMF irradiated by HVTL on learning and memory of rats: We also used BI-2000 Morris tracking analysis system and Morris water-labyrinth experimental method to study the changes of capabilities of learning and memory of Wistar albino rats after the action of the environment electromagnetic fields irradiating by HVTL in accordance with standard method in biology and medicine. 22 Wister albino rats are separated as the experimental and controlled groups containing 11 rats of 6 male and 5 females. 11 rats in the experimental group were exposed in the electromagnetic field (EMF) irradiating by HVTL about 400 days at 27°C, where their exposed time in each day is about 16 h as mentioned above.

In this experiment, we first train these rats to learn and seek freely an object by virtue of the swimming in a standard swimming bath in Morris water-labyrinth. 11 Wister rats in the controlled group do also similar learning and seeking experiments. After three days, let them seek the correct placement and position of the object via swimming in the Morris water-labyrinth. Subsequently, at 4^{th} day we measured and record the time seeking the object or plane-stake for each rat in the Morris water-labyrinth. We deal finally with these experimental data of seeking times by using SPSS software. The results obtained are listed in TABLE 6 for the controlled and experimental groups [1,2,29,30].

TABLE 6: **The time (second) seeking the object of the rats in the experimental (EG) and controlled groups(CG) in the experiments of Morris water-labyrinth.**

Number of rat	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
CG	53.00	51.75	103.27	60.02	13.77	11.76	28.50	12.75	13.75	10.76	27.75
EG	69.02	18.27	117.50	104.22	116.74	117.49	28.76	18.76	36.75	72.28	43.34

From this TABLE 6 we know that the times seeking the plane-stake for these rats in two groups are obviously different, the seeking times of the rats in the experimental group are obviously larger than those in the controlled group. Therefore, we can conclude that the capacities of learning and memory of rats after the action of the environment electromagnetic fields irradiating by the HVTL are decreased with respect to the controlled group, the difference is distinct ($P<0.05$).

Discussion

In the investigation of influences of EMF irradiated by HVTL on brain electrical information in rats we obtained the EMF can vary the features of brain electrical information in rats, in which the properties of power values of wave sections of δ, θ, α, β are changed under action of the EMF, although their variations are small ($P>0.05$). In order to confirm the correctness of the conclusion we measured the infrared spectrum of brain tissue, which have an insight into its structure of molecules and their variations. The result is shown in FIG. 6, which exhibits that a new peak of 2345.40 cm^{-1} appears under influence of EMF irradiated by HVTL. This indicates the variations of structure of biomolecules, such as protein molecules, in the brain tissue in this case. This means that the mechanism of change of brain electrical information in rats is just the variations of structure of the biomolecules in them arising from EFM irradiated by HVTL Therefore we should believe and affirmed that EMF irradiated by HVTL can interference and vary the states and features of the brain electrical information of rats.

The above alternations of brain electrical information can also affect the bio-functions of brain. In this case it is not strange or necessary that the learning and Memory of rats are varied under influences of EMF irradiated by HVTL, which are shown and demonstrated in TABLE 6.

We can also affirm the influences and interference of EFM irradiated by HVTL on the muscle electric information of rats, which embody the natures of activity of bio-electricity of skeletal muscle, based on the results obtained from the measurements of the states and property of muscle electric information of rats under action of EMF irradiated by HVTL, which is shown in TABLE 4., there we inspected the incubation period and amplitude size of CMAP and found that they are significantly changed($P<0.05$). Very obviously, the variation of CMAP can affect the states and features of the nerve cells in this part as well as the behaviors of neighboring nerve cells, thus a new action potential occurs in the muscle tissues, which can transfer along the nerve systems. This manifests that the variations of CMAP can denote and mark alternations and damages of nerve information and structure. The experimental results in TABLE 4 indicated significant variations of CMAP under affection of EMF of HVTL, then we can determine that EMF irradiated by HVTL can interfere and influence

significantly the electric-physiological features of nerve tissues and transfer of nerve information in muscle tissues through the depolarization of nerve cells arising from the changes of CMAP. Therefore, we can affirm that EMF irradiated by HVTL can influence and interfere the muscle electric information of rats [1,2,29,31,36,37].

At the same time we obtained from the experimental results in table 4 obtained by the multi-channel physiological signal acquisition processing system that the EMF irradiated by HVTL can affect and interfere the heart electrical information in rats, which are embodied by the following facts, namely, the period of motion of the heart is evidently extended ($p<0.01$), the ratio of heart beating is greatly shorted ($p<0.01$), the peak of T wave is greatly increased ($p<0.05$), the schedule of T wave is obviously extended ($p<0.05$), the schedule of P wave is obviously extended ($p<0.05$), but the changes of schedules and peak value of QRS are small ($p>0.05$), QRS peak little change ($p>0.05$), the variations of period of QT and PR as well as peak values of P wave are also small ($p>0.05$). These alternations result in the variations of bio-function of the heart. These problems are described as follows.

For example, the obvious lengthen of schedule of P wave will lead on the slow of speed of transfer of the nerve excitement along the transfer system from the sinoatrial node to the ventricular muscle on both sides through the junction between the beam, atrioventricular node, Bush's beam, left and right bundle branch, Purkinje's fibers. This means the depressions of activity of Na^+-K^+-ATPase on the membranes of self-discipline myocardial cells and atrial muscle cells, the former makes the speed of transfer of the nerve excitement become slow, the latter gives rise to the lengthen of schedule of action potential of atrial muscle cells. In this case the slow of depolarization and repolarization of the tissues on both sides of the atria occurs [1,2,29,31,36,37].

Because P wave marks the process of depolarization in both sides of the atria, i.e., it designates the sizes of time of transfer of nerve excitement from the sinoatrial node to the atrioventricular node through the atrial conduction organization (room beam and beam), PR wave section characterizes the size of time of transfer of nerve excitement from the atrioventricular node to the ventricular muscle cells on both sides through the Bush's beam, left and right bundle branch, Purkinje's fibers, then their sum is just the time of interphase of PR wave.

Then the lengthens of schedule of P wave and PR wave imply that the retardant and damping of transfer of the nerve excitement from the atrioventricular node to the ventricular muscle cells on both sides are increased under the influences of EMF irradiated by HVTL, which is great than the time of transfer of the of nerve excitement from the sinoatrial node to the atrioventricular node. Its reasons are possibly due to the damage of Ventricular conduction organizations (Bush's beam, left and right bundle branch, Purkinje's fibers) in special transfer tissues, such as self-discipline organization after action of EMF irradiated by HVTL. Certainly, this mechanism need study further [1,2,29,31,36,37].

Because the duration of T wave and its strength of peak are increased after action of EMF of HVTL, which is shown in TABLE 4, then the bio-functions of the atrial muscle cells and self-discipline organization will be degenerated, or speaking, the capability of resistance on the influence of externally applied EMF of HVTL is decreased in this case, thus the damaged effects of EMF irradiated by HVTL are embodied and exhibited in the experiments as shown in TABLE 4. Thus, we believed

and confirmed from this investigation that EMF irradiated by HVTL can affect and interfere with the heart electric information of rats.

Conclusion

In this paper, we have done epidemiological survey for the influences of EMF irradiated by HVTL on human health and inspected further the variations of physiological features of peoples, such as the brain, hearth and muscle electric information using EGI SYSTEM 200 brain electrical information instrument with 250 channels and multi-channel physiological signal acquisition processing system, respectively. From the epidemiological survey for the variations of hearth of peoples living in EMF irradiated by HVTL relative to the normal peoples, who live in the environment of no electromagnetic irradiation, we found that EMF irradiated by HVTL results in the memory loss, distracted, high increase in blood fat, significantly increase of the chronic diarrhea, anemia, and incidence of hoarseness symptoms, but it depressed the incidence of leukopenia and thrombocytopenia symptoms. Otherwise, the influences EMF irradiated by HVTL on the hearth of women are smaller than those of men we obtain. For the men, the memory depression, hair loss, anemia, increase of sweat and diseases of eyes, nose and throat are easily occurred under the influences of the EMF of HVTL [1,2,9,29,30].

Otherwise, the difference of influences of EMF irradiated by HVTL on the peoples between different blood types are not significant. On the other hand, EMF irradiated by HVTL increase the indexes of the electrocardiogram (ECG), electromyography, and electroencephalogram (EEG). Therefore, we can affirm from this investigations that EMF irradiated by HVTL can influence the hearth of men and women, but their influences are different.

At the same time, the influences of environment electromagnetic fields irradiated by the high-voltage transmission lines on the brain, heart, and muscle electrical-information as well as the memory function of brain in animals are measured and inspected by EGI SYSTEM 200 brain electrical information instrument with 250 channels and multi-channel physiological signal acquisition processing system in this paper. The results obtained indicate that EMF irradiated by HVTL can influence, interfere, and vary the properties of the images of the brain, heart and muscle electrical-information of the animals in different degrees. This means that environment electromagnetic fields irradiated by the high-voltage transmission lines can influence the functions of the brain, heart, and muscle electrical-information of animals. The reasons arising from these variations are due to the alternations of the structure and features of biomolecules in these tissues caused by the EMF irradiated by HVTL. These results have the important significances in biology, bioelectromagnetic and biophysics.

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Declaration of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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