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The influence of Wi-Fi range electromagnetic radiation on the parameters of the human's heart variability

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Abstract. The issue of the effect of Wi-Fi range (WFR) electromagnetic radiation (EMR) on the human's body has recently become topical due to a considerable growth of the abundance and exposition of this factor. The energy evaluation of the influence is a complicated task due to the phenomenon of superposition of multitude Wi-Fi sources, effecting humans simultaneously. The paper studies the effect of the Wi-Fi source's electromagnetic radiation on the cardiovascular and vegetative nervous systems of the human. The effect of the WFR electromagnetic radiation, being expressed by the reliable change in the parameters of the heart rate variability (HRV), on the cardiovascular system state was studied. The results the reliable influence of WFR on the HRV parameters on the background of the psycho-emotional load was exposed; the HRV parameters included the mode (Mo), an average heart rate (HR) and the coefficient of the variation (CV). The changes of the indicator of the regulation processes' adequacy demonstrate regulatory mechanisms' decentralization under the complex influence of factors. The index of the regulatory systems' tension increases during the combined influence of WFR and psycho-emotional load, ipso facto, violating the adequate regulatory reaction of the body towards the decrease of the adaptive abilities.

1. Introduction

Nowadays the world population lives in an absolutely new electromagnetic environment which has never existed during the whole evolution period [1]. One of the sources, forming this environment in the radio frequency range, is a wireless connection of modern communication devices, the active introduction of which into our life is growing day by day. The wireless connection is, mainly, presented by the mobile communication, the work of which is regulated by sanitary and hygienic requirements, as well as by Wi-Fi radiators, having practically an uncontrollable influence on the human (constant, twenty-four-hour, forced chronic radiation (24/7) of all the population's groups by pulse polarized radio frequency electromagnetic radiation (EMR RF)). Exactly this influence is of a determining character, it changes in a wide intensity range, it may have a different frequency characteristic and it irradiates the whole body totally. Effective and mass protective measures against this kind of impact are absent. It is necessary to admit that the scientific data for the evaluation of the danger of constantly changing conditions of EMF RF influence on the population is insufficient, and



the obtained results of the scientific researches into prolonged influence of WFR on the human's body are often contradictory.

The issue of a biological action of the WFR electromagnetic radiation is important due to some reasons: 1) this type of impact is not specified by the conception of the voluntary risk, i.e. the person is not notified about the factor's effect; 2) the influence has a considerable exposure (in the urban environment the human is almost always exposed to this type of EMR 7/24 – at home, at work, in the transport, etc.); 3) the energetic impact assessment is a complicated and not always a solvable task due to the phenomenon of superposition of many WFR sources, effecting people simultaneously. And a special reason is the spread of Wi-Fi in educational establishments; this provokes a particular anxiety as the object under the influence is children and teenagers. The means of communication, working in the radio frequency (RF) range, have become an integral part of the modern human's life, including children, teenagers and young people. Along with this, the diseases of the cardiovascular system are at the top of the general sickness rate structure, and an evident rejuvenation and a tendency to the growth of this pathology can be observed. Twenty-five years ago, when the era of mobile communication only began, the anthropogenic pollution of the environment was well-predictable, there were regulatory documents, and the conception of thermal influence of the electromagnetic radiation of the radio frequency range (EMR RFD) was accepted as an axiom. That situation was characterized as harmless "electromagnetic smog". Nowadays, twenty-five years later, this situation can be characterized as "electromagnetic chaos", which the scientific and political communities start being aware of. In essence, the epoch of "electromagnetic outrage" is the electromagnetic pollution of the environment [16]. Since the spread of the wireless connection in the radio frequency range a series of researches on its biological activity was carried out; the results of the research, despite their contradictoriness, show that EMR RF may influence negatively the health status. As of today we can single out a series of works, demonstrating the risk of origin of insomnia [12], depression, hypertension [10], the influence on the activity of some areas of the human brain [15], the lowering of humans and animals' spermatozoa mobility [14]. And an absolutely special situation emerged due to the extensive spread (in most cases irradiating us without notification) of the Wi-Fi standard wireless connection. There is a serious concern about probable consequences for the health under the influence of Wi-Fi radiation [20]. WFR has a range of peculiarities determining their influence on biological structures (nonthermal intensity, pulse character and polarization) [4] and this causes a set of requirements to the experimental works. Considering these peculiarities, 7 main Wi-Fi effects were found out: oxidation stress [23], damage of the cellular DNA [3], acceleration of apoptosis [18, 19], neuropsychiatric effects [13], the reduction of the spermatogenesis [7], endocrinal effects [8] and "calcic transfer" (the activation of calcium transportation) [19, 20].

Nowadays there is a contradictory situation concerning probable risks of Wi-Fi EMR influence on the human body. Thus, in some countries (France, Russia) the usage of WFR in educational establishments is not recommended by competent organizations, while in others (England, Canada) the structures, controlling this issue, claim about the absence of risks for the human health. A similar situation is among the researchers, this is presented in the review article [22], in which on the basis of more than 100 works on studying the WFR (2.45 GHz) biological activity it was concluded that this factor causes a trustworthy damage of the reproductive system, influences the characteristics of electroencephalogram and brain's functions, it also influences the heart, the liver, the thyroid gland, the genes expression, the cellular cycle, and the cellular membranes. Many researchers assume the oxide stress as the action mechanism. The side effects on studying, memory, attention and behavioral reactions are the results of the cellulotoxic effects. As opposed to the above-stated, there are works [6, 20] which critically treat the results of the experimental researches on the WFR influence on the bioobjects. To date the information about EMR WFR influence on the cardiovascular system is of a single and quite cautious type [9, 24], the change of the rhythm of heart smashing and blood pressure was reliably found out [9, 21]. In connection with the above-stated, the study of the cardiovascular disorders' origin under the influence of EMR WFR is topical and timely. A cardiovascular system (CS)

is a very sensitive and sufficient objective criterion for the evaluation of the low-intensive EMR, namely WFR, influence.

2. Task setting

The objective of the research was to study the influence of electromagnetic radiation of radio frequency range, used in the Wi-Fi systems, on the parameters of the human's heart rate variability. To achieve the aim the following tasks were set: 1) to determine the parameters of the heart rate variability (HRV) under the influence of sensory, electromagnetic and combined irritants on the human body; 2) to carry out a statistical analysis of the parameters of the heart rate variability under the influence of the considered irritants and their combinations.

3. Methods

Thirty-five conditionally healthy volunteer students at the age of 18-20 took part in the research. All the subjects voluntarily agreed to participate in the research. The experiment was carried out in a special premise guaranteeing the minimization of the outer irritants. The preliminary HRV research allowed forming a homogeneous group of volunteers with HRV parameters which did not exceed the physiological norm limits. The heart rate variability was determined by the computer appliance REAKOR (by the scientific manufacturing design company "Medicom MTD", Taganrog). The psycho-emotional load was created using the functional test by the reverse calculation method according to Kraepelin [2]. The influence of the electromagnetic radiation of a Wi-Fi wireless connection device on the human body was accomplished with the help of the router of model D-Link (model – DSL-2740U); the density of the radiant flux in the distance of 1.00 m was $0.85 \mu\text{W}/\text{cm}^2$.

The research was done at 4 stages: 1) the control (the electrocardiogram was done in the quiescent state for 5 minutes with a false WFR influence (placebo)), 2) the experiment (the electrocardiogram was done under the psycho-emotional load), 3) the experiment (the electrocardiogram was done in the quiescent state under the WFR influence), 4) the experiment (the combined influence of the psycho-emotional load and WFR). To evaluate the WFR influence on the body the method of HRV mathematical analysis was used (in the system of evaluation, recommended by the standards of the European Cardiology Society and the North-American Society of Stimulation and Electrophysiology [17]). The experimental data were tested for normalcy of distribution according to Kolmogorov – Smirnov test. In the series with normal distribution an average value and an error of mean were calculated, in the series with the distribution, different from the normal, the median, the upper and lower quartiles were calculated. The credibility of the difference for the normal distribution was evaluated by Scheffe test, for the evaluation of the distribution, different from the normal, Kruskal-Wallis test was used.

4. Results and discussion

The experimental data of the carried out researches on the influence of Wi-Fi wireless connection devices' electromagnetic radiation on the parameters of the human body's heart rate variability are presented in Table 1.

As it is seen from the data above, a trustworthy increase of the stress index SI (characterizing the degree of the nervous system influence on the heart work) was observed in the experimental Groups 2 and 4 in comparison with the control group. The stress index (SI) of the body's regulatory systems is an integral parameter, characterizing obviously the level of the central regulation contour of the heart's work, and the most sensitive to the fluctuations of the sympathetic ANS influences. The parameter grows under the load and at the stabilization of cardio intervals during the activation of the sympathetic ANS. Under the psycho-emotional load this parameter grew reliably, this corresponds to the normal reaction of the body to the irritant. At the same time under the WFR influence an insignificant decrease of the parameter is observed in comparison with the control group, but these changes are not reliable statistically. Under the complex influence of EMR factors and psychic load SI increased reliably in comparison with the control. However, in comparison with Group 2 SI in Group

4 decreased slightly, this may evidence about the disorder of heart rate regulation mechanisms under the influence of psycho-emotional load in complex with Wi-Fi EMR.

Table 1. The change of the heart rate variability parameters at the creation of the emotional stress and the effect of the WFR electromagnetic radiation on the human (n=35).

The VHR parameters	Group 1 (control) M±m	Group 3 (EMR WiFi) M±m	Group 4 (combin.) M±m
SI (stress index)	73.45± 4.28	68.18±1.99	83.45±4.04
P ₁ (with Group 1)	-	-	0.032
Mo (mode)	828.8±11.6	816.9±12.1	737.4±8.9
P ₁ (with Group 1)	-	-	-
P ₂ (with Group 2)	-	-	0.040
Amo (amplitude of mode)	0.277±0.011	0.264±0.014	0.316±0.012
P ₁ (with Group 1)	-	-	0.034
SDNN (mean-square deviation)	63.2±2.21	65.7±3.11	54.9±1.70
P ₁ (with Group 1)	-	-	0.049
P ₂ (with Group 3)	-	-	0.028
CV (coefficient of variation)	7.11±0.27	7.48±0.14	6.73±0.31
P ₁ (with Group 1)	-	-	-
P ₂ (with Group 2)	-	0.01	-
P ₂ (with Group 3)	-	-	0.016
HR (average heart rate)	72.16±1.54	74.86±2.35	73.39±2.46
P ₁ (with Group 1)	-	-	-
P ₂ (with Group 2)	-	-	0.037
IARP (index of adequacy of regulation processes)	34.08±1.61	34.97±1.45	38.83±1.31
P ₁ (with Group 1)	-	-	0.034
P ₂ (with Group 2)	-	-	0.046

The values of the distribution mode (Mo) differed reliably between the control and the experiment only in 3 and 4 series of observation. The value of the distribution mode (Mo) is the most frequently met duration of the cardio interval in the selection. The changes indicate the fluctuation of the humoral regulation canal's functioning level and long-term adaptation of the blood circulation system [25].

The values of the model amplitude Amo (it allows estimating the real state of regulation systems and reflects the stabilizing effect of the heart rate control's centralization) differed reliably between the control and the experiment only in 4 groups of observation; this is an important evidence of a reliable WFR influence on the HRV of the human.

Mean-square deviation SDNN (reflects all the periodical variability components during the recording time, i.e. is a total HRV index) also reduced reliably in Groups 2 and 4 in comparison with the control one; a reliable decrease of this parameter in Group 4 with respect to Group 3 was also exposed. The reduction of SDNN emerges under the stress of regulatory systems and the rhythm stabilization, it is followed by the increase in the number of homotypic cardio intervals. Under the influence of Wi-Fi EMR only the SDNN change is not reliable, however, on average this parameter grew insignificantly in comparison with the control. A reliable increase of this parameter in Group 4 in comparison with Group 3 evidences an insufficient mobilization of the functional body's reserves in the case of the combined factors' action.

The coefficient of variation (CV) is a standardized in the average rhythm value estimation of the mean-square deviation, CV has a complex character of changes at different stages of the experiment, with a reliable decrease in Group 2 as regards to the control group (Group1), in Group 3 there is a reliable growth of the parameter as regards to Group 2, and in Group 4 a reliable decrease of this parameter in comparison with Group 3 is observed.

The heart rate (HR) increased reliably under the psycho-emotional load in Group 2 in comparison with the control group, and decreased reliably in Group 4 (the combined action) as regards to the same group, Group 2.

While calculating the index of adequacy of regulation processes ($IARP = A_{Mo}/Mo$), reflecting the correspondence between the activity of the sympathetic regulation canal and the autonomous contour of the Keith-Flack node regulation, the growth of IARP in experimental Group 4 as regards to control Group 1 and experimental Group 2 is exposed; this is connected with the insufficient centralization of the regulation processes under the Wi-Fi EMR influence.

5. Conclusions

The WFR influence on the cardiovascular system, manifested in the reliable change of the HR parameters, was demonstrated experimentally. According to the evaluation of the following parameters, Mode (Mo), an average HR and CV, we may speak about the insufficient activation of the central regulation contour and sympathetic ANS under the combined influence of psycho-emotional load and WFR. The calculation of IARP indicates the decentralization of the regulatory mechanisms under the complex influence of factors. The index of regulatory systems' stress increases under the influence of WFR and psycho-emotional load, thus, violating the adequate regulatory reaction of the body towards the decrease of the adaptive abilities.

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