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Is there a relationship between a human ECG and blood glucose. Experiments and hypothesis.

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Abstract

The paper presents the results of experimental studies that suggest the existence of cause-effect relationships between the process of changing the level of human blood glucose and its electrocardiograms (ECG)

During the studies, the ECG of several people of different ages and physical conditions was recorded simultaneously with the observation of the dynamics of the level of blood sugar in these same people.

As a result of the experiments, for the first time it was possible to establish that in all the subjects, with an increase in the level of blood glucose, there was a decrease in the activity of the ECG

contour movement. In classical electrocardiography, the motion of an ECG contour is considered a hindrance and does not have any diagnostic information “in principle”. The experiments conducted by the authors of the article suggest the relationship between the most important physiological structures of man.

The results of the experiments are important both for physiology and for practical medicine, as they open up prospects for the development of methods for non-invasive continuous diagnosis of the dynamics of human blood glucose levels. This is extremely important for correcting the condition of patients with diabetes mellitus. The absence of such information seriously complicates the work of modern correction systems. including insulin pumps., Research data is an example of a practical study of dynamic electrocardiography - a method. proposed in previous articles.

Introduction

One of the problems of diagnosing the state of the human body and its functional capabilities is the most complex mutual influences of completely different in nature factors, what cybernetics call cross-connections. In order to exclude these mutual connections, it is necessary to build multi-pass experiments or observe very harsh conditions during examinations.

So, for example, an electrocardiogram (ECG) for cardiologists is informative only if it is registered in a state of complete rest of the patient. In turn, endocrinologists examine glucose metabolism with minimal external "disturbing factors": meals or exercise should be "delayed" in time from the examinations for 3-4 hours, or vice versa, the examination should be carried out immediately after eating - sugar known volume. In this case, of all the possible functions of the body, speaking the language of cybernetics - functional connections - one stands out - the work of the pancreas.

The use of cybernetic research methods in medicine and physiology, along with other methods, “suggests” to analyze the dynamic relationships between various structures of the body. using synchronous recordings of diagnostic information A striking example of such a “combination” of dynamic information is the level of blood glucose and ECG - an element of the so-called “glucocardiomonitoring”.

To solve these problems, special control tools and diagnostic theories are developed. Such studies should include the development of a means of continuous monitoring of the ECG and the proposed basic provisions of a dynamic ECG described in previously published works [3-5].

Question status. Statement of the problem.

Patients with insulin-dependent diabetes mellitus (type 1) are, among other things, at risk for human cardiovascular systems (CVS), for the risk of myocardial infarction, coronary heart disease and sudden death.

The works on human CVS in diabetes analyze in detail the "destructive" effects of diabetes. especially with long periods of illness. [2]

Professor A.S.Ametov and colleagues. [1],made a very large contribution to the comprehensive study of diabetes and cardiology. They introduced the concept of glucocardiomonitoring and conducted numerous experiments on the simultaneous recording of glucose levels and ECG parameters, while it was found that cardiac complications (extrasystoles, increased heart rate, etc.) occur more at low (< 3.5 mmol per liter) and a high (> 8 mm \ l) sugar level, violations of certain ECG parameters have been established, but no direct “physiological” relationship between sugar level and any ECG parameters has been established [1].

At the same time, a large number of studies on the relationship between the physiology of the heart and diabetes are devoted to long-term mutual influence [2]. as a rule, the effect of diabetes on blood vessels and heart structures. The serious consequences of this relationship are not in doubt. however, this mutual influence cannot be attributed to dynamic relationships. And not only because of the rather long time intervals of their manifestation. but also because that this relationship manifests itself after serious structural changes in the human body.

Recently, much attention has been paid to non-invasive control of blood sugar levels [7]. This is basically. optical methods that "monitor" the spectral composition of the blood and use various types of teston radiation. . In these devices, the ECG signal is not used.

Recently, attempts have been made to use “artificial” intelligence to establish the relationship between glucose metabolism and ECG variations. However, in these works [6], the relationships between heart rate variations and long-term structural changes in the human body are studied —

for example, changes in heart rate variations and the stage of diabetes. [6]. These studies have a very “indirect” relationship to dynamic relationships.

It can be assumed that these connections are quite "thin" and they can only be established using a high-precision ECG recorded for a sufficiently long time.

Experimental data

During the experiments, observations were made of patients without critical exacerbations of any diseases with significant differences in physiology.

During the experiments, various ECG and blood sugar levels were used.

In the first experiment, the observations were made on a man aged «60+» with 25 years of experience of «type 1» diabetes mellitus-insulin-dependent diabetes and with many complications caused by this chronic disease.

A glucose sensor was installed in the patient and the level of sugar was continuously monitored for a week. One day, during the day, a Holter cardiac monitor was installed in this patient.

In general, the examinations did not show any cardiac problems - there were no extrasystoles, significant arrhythmias, or changes in cardiac complexes. Changes in blood sugar during the day were repeated, while, as a rule, time intervals were observed with low sugar, high and normal. Using Holter ECG treatment programs for low and high sugar intervals, detailed ECG and heart rate were obtained and comparisons were made. In addition, an accurate ECG registration system was used, which recorded an ECG for 1-2 minutes with the ability to calculate heart rate and ventricular activation rate by the method, set out in [3-5]

The results were as follows:

In three states - with high sugar level (10-11 mmol per liter), normal (6-7) and low (3.5-4), it was possible to establish differences in the -motion of the ECG contour, -decrease in the "mobility" of the ECG contour with increasing blood sugar level and vice versa - with a decrease in sugar level, the amplitudes of the ECG contour movements increased from 2 mV mV to 5-7 mV.

An example of electrocardiograms in a “compressed” scale is shown in Fig. 1. Here, in Fig. 1a, the ECG with a sugar level is 5.6 mm \ L, and in Fig. 1b, at -11 mm \ L. With a high level of

sugar, the amplitude of oscillations is from 2 to 5 mV. at low from 5 to 10 mV. The human load was approximately the same.

It should be noted that the movements of the ECG contour increase in amplitude with decreasing sugar level, despite the filters of the contour movements, which are very effective with standard ECG monitoring techniques, including in the "Holter" version. One of the tasks posed by the authors is to establish a relationship between the most important ECG parameters and blood sugar. These parameters included - the amplitude of R - teeth, heart rate and SAS, calculated by methods. set forth in [3-5] However, to date, such a relationship could not be established. .

Fig. 1. The patient's ECG "1" when: a) 5.6 mm / l; b) 10.6 mm / l.Let us dwell on the behavior of the ECG contour.

Discussion of results and comments.

The ECG contour is a common electric potential for the entire human cardiac system, by changing which one can achieve a change in the structure of the ECG complex and any change in heart rate

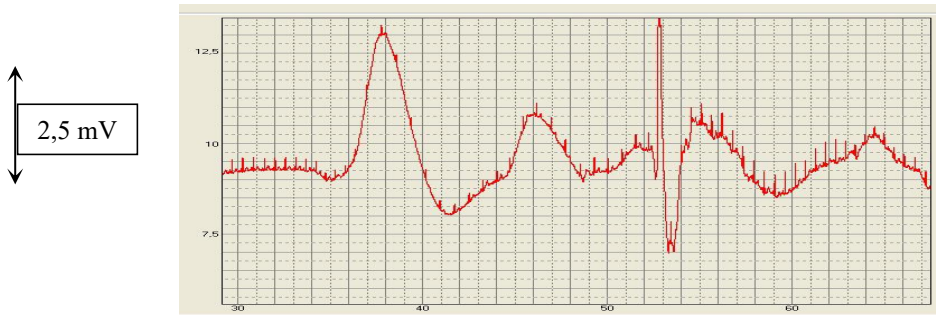
In electrocardiography, the movement of an isoline is considered an interference. To analyze and, even more so, to establish any laws of its "behavior" is considered "bad form", however, the various experiments carried out over several years cast doubt on these principles.

In this regard, in order to determine whether the observation data are random and whether they are universal in nature, including for healthy people, the tests were continued with other participants and other equipment.

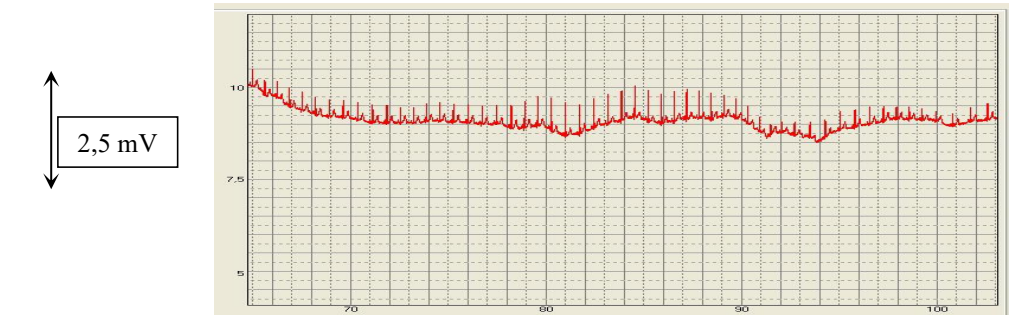
Two trained athletes were connected to the experiments - 25 (C1) and 40 years old (C2) and one healthy girl 25 years old (D1).

Experiment Continuation Results

In the course of the experiments, I standard ECG abduction was recorded at a normal sugar level, ECG after an increase in glucose level and after its decrease. ECGs were recorded for approximately 1 minute. The subjects during this time performed a simple test: holding the breath, restoring breathing, muscle tension and performing several deep breaths.



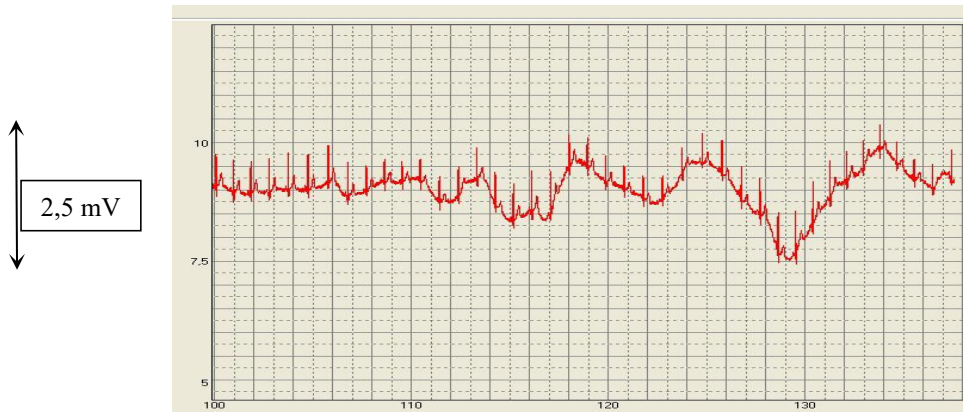
a)



b)

Fig. 2. ECG of the examined “C1” with: a) 5.8mm / l; b) 8.8mm / l

a)



b)

Fig. 3. ECG of the examined "C2" with: a) 5.1mm / l; b) 7.8mm / l

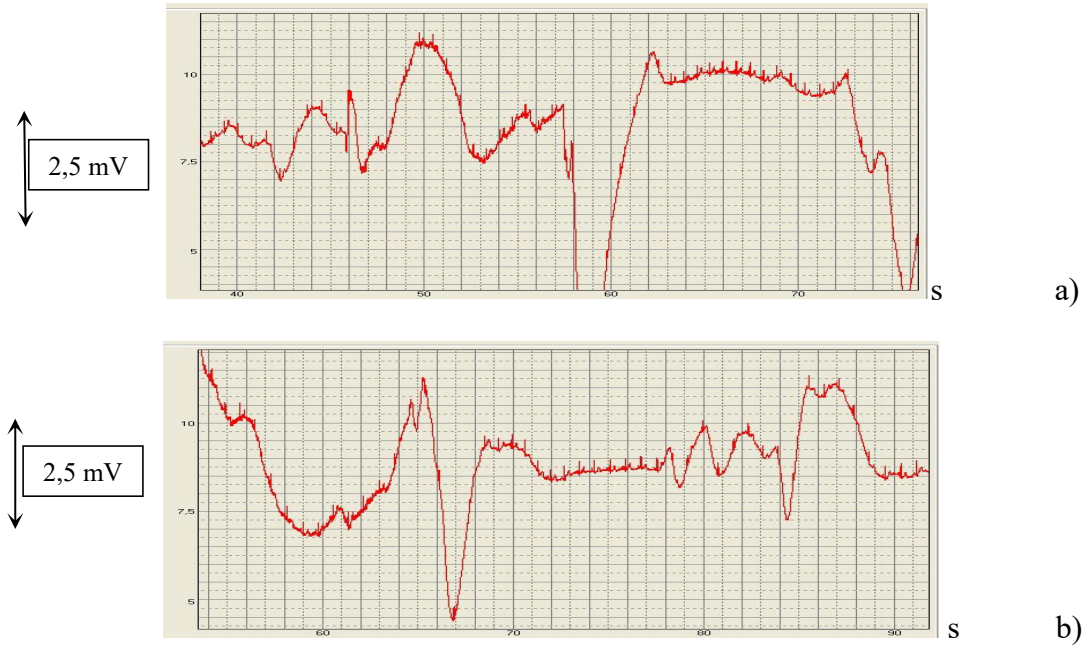


Fig. 4. ECG of the examined "D1" with: a) 5.8 mm / l; b) 6.8 mm / l

As follows from the examples of electrocardiograms presented in Fig. 1-4, the activity of ECG contours decreased in all participants with an increase in blood sugar level. In the last example, the differences are insignificant due to the fact that in a healthy girl with unprofessional physical training, when performing motion tests, the contours were significant and with normal sugar, and to achieve a significant increase in glucose levels failed.

It should be noted that with normal electrocardiography - at rest - all 4 subjects had very similar results, even in a person of 64 years with a complex of chronic diseases, the analysis of the daily ECG was quite satisfactory.

The experimental results showed the following:

1. In all subjects, with an increase in blood glucose, the amplitude of fluctuations in the ECG contour decreased.

2. Fluctuations in the ECG contour of non-athletes were significantly higher, as well as heart rate fluctuations, moreover, they were less dependent on glucose levels.

To refine the research results, another experiment was conducted with a different ECG recording system.

A 40-year-old athlete is a weightlifter of a high level of training (III1), whose ECG was recorded for 40 minutes. Registration was carried out using an ECG T-shirt designed and manufactured at SUSU. Its feature is five electrodes made of a material with a shape memory effect coated with a conductive fabric with silver threads, described in detail in [5]. There are 5 electrodes in this product - 2 on the left and three on the right. They are connected in two groups of "left-right", registering the "integral ECG vector." The ECG was recorded in two long intervals of 15-20 minutes. In the first 15 minutes, the athlete's glucose level was 5.4 mmol per liter, in the second - 9.2. In both intervals, the athlete performed the same physical exercises, alternating with calm time intervals. Figures 7 and 8 show ECG signals "compressed" in time, obviously. that with elevated sugar levels (Fig. 5), there are practically no movements of the ECG contour

In the diagrams (Fig. 5 and 6), changes in the position of the ECG axis are obvious. At several points of the ECG (Fig. 5) - when an athlete performs the exercises, the R-wave changes and even changes sign. At the same time, there are almost no noticeable isoline movements, with an increased glucose level, these fluctuations have an amplitude of 1-2mV (Fig. 5), against 8-10mV (Fig. 6) at a normal sugar level.

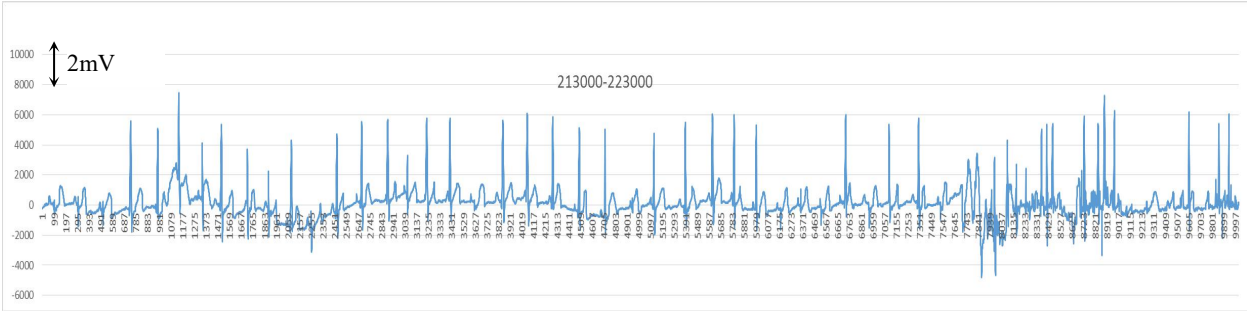


Fig. 5. (9,2 mm\l)

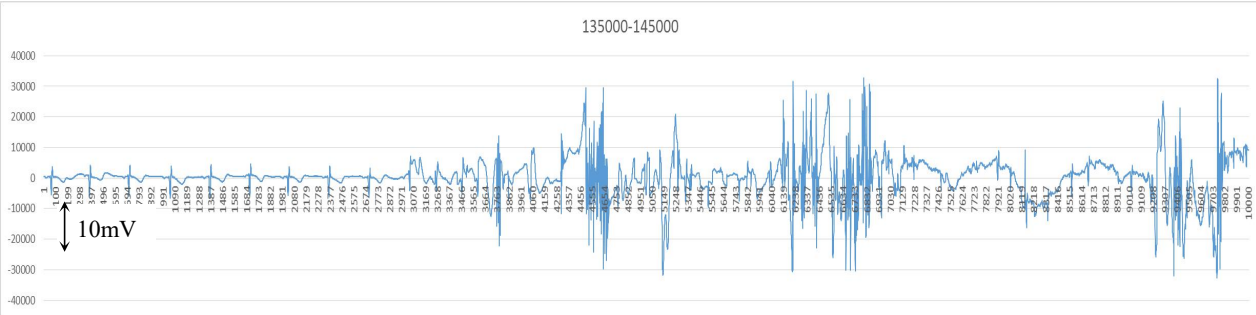


Fig. 6. (5,4mm\l)

As for the movement of the contour. then the following hypothesis is proposed

Given that "The idea of an electrocardiographic curve as the sum of subendocardial transmembrane action potentials is very interesting, because it helps to clearly understand the electrophysiological mechanisms .." [8, 9,10] and these mechanisms are determined by threshold values of electric potentials, it becomes obvious. that variations in the level of the zero line of this sum — which is the ECG isoline — by up to 10–12 mV will interfere with the operation of mechanisms with threshold values. and, therefore, change the phases of the cardiocycle or the duration of the intervals.

What does it mean and how to use it

The most important result of the experiments, according to the authors, is the confirmation of the existence of a dynamic relationship between changes in blood sugar levels and the behavior of the electrical potentials of the cardiac system.

It can be assumed. that a change in blood sugar level carries a change in blood density and to maintain the necessary blood flow in the CVS, it is necessary to change the parameters of the control signal for the myocardium - any ECG parameters As mentioned above, at the present time, it was not possible to establish a reliable interaction of glucose level and any parameters ECG besides isoline activity. This dependence confirms. that there is such a dynamic connection. Since the activity of the zero line should interfere with the operation of mechanisms with threshold values, there should be a mutual influence of ECG parameters and blood composition. They need to be established by more accurate and thorough experiments.

As for the established connections, when confirming their existence, their effective use is possible by means of continuous diagnostics - ECG-t-shirts. belts, etc., which can stably measure

ECG and the dynamics of its contour for a long time. Information on sugar levels or trends in their measurement can be used to monitor the condition of patients with diabetes (Today. In the most advanced glucose meters and pumps, the correction is very inaccurate due to the significant time delays between meals. Changes in blood sugar and sugar in copillaries. where direct measurement takes place Sugar trend information is very useful in such systems.

It should also be noted that it is easier and faster to observe changes in the variability of the ECG contour line. than heart rate variability - this is the prospect of a diagnostic future method for continuous monitoring of the ECG and its contour.

Whether these changes are the cause or effect of changes in cardiocycles is a matter of independent research. The very relationship between these processes is important. which. in the opinion of the authors, is obvious.

Observations. suggestions and hypotheses formed based on their results can be considered one of the examples of the implementation of the principles of dynamic electrocardiography set forth in previously published works [3-5].

Data available on request from the author.

The data that support the findings of this study are available from the corresponding author upon reasonable request**.**

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