ИНФОРМАЦИОНН0-КОММУНИКАЦИОННЫЕ ТЕХНОЛОГИИ

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A STUDY OF ELECTROCARDIOGRAPHIC CHANGES IN TYPE 2 DIABETES MELLITUS PATIENTS

Diabetes, which is known since the early I century, is an illness with a large number of types and affected people and it has become one of the global problems. From them, type 2 diabetes, which has many affecting factors, is one of the most common types of diabetes. The objective of our study is to determine the sugar levels of patients with Type 2 diabetes through a non-invasive method which does not cause infections, that is the electrocardiogram (ECG). The study lasted for two days. There were two parts of the experiment: one was carried out on an empty stomach until 8:00 on the first day, and the second one was done two hours after eating on the second day until 20:00. In order to compare the results the sugar levels of 20 women and 32 men with Type 2 diabetes were determined with an electrocardiogram and a glucometer. Data on gender, age, overweight, duration of illness, smoking habits, income, parental history of diabetes, early cardiovascular disease (CVD) was collected accordingly. The results of the study show that in patients with Type 2 diabetes the S, T, ST, QTc, QRS intervals of electrocardiogram (ECG) change and sugar levels are higher in the evening than in the morning.

Key words: *type 2 diabetes mellitus, electrocardiography, electrocardiosignals, non-invasive method, cardioanalyzer.*

Introduction. Diabetes is one of the widely spread diseases worldwide and among its various types the proportion of patients with Type 2 diabetes is about 90% higher than the number of patients with Type 1 diabetes, gestational diabetes, and other types. According to previous statistics, the majority of patients with Type 2 diabetes were adults, particularly men, and citizens of sedentary countries with low incomes, but nowadays adolescents and young people are also suffering from Type 2 diabetes. According to statistical data obtained from the Almaty department of the "Republican Electronic Health Care Center", the growth rate of diabetes mellitus over the past 5 years is shown in Figure 1.

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In worse cases of Type 2 diabetes, there is a high chance of patients developing diseases of the brain, kidneys, bones and joints, eyes, their nervous system, and cardiovascular system. Patients with Type 2 diabetes must keep blood sugar levels under control constantly to avoid complications. There is currently the invasive detection of diabetes in use which is done by inserting a needle or laser into the finger, wrist and abdomen, but it can cause infections and be painful for patients. The heart has a great connection to the human life conditions, hence patients with Type 2 diabetes who often have heart problems should be tested using an electrocardiogram, a non-invasive method.
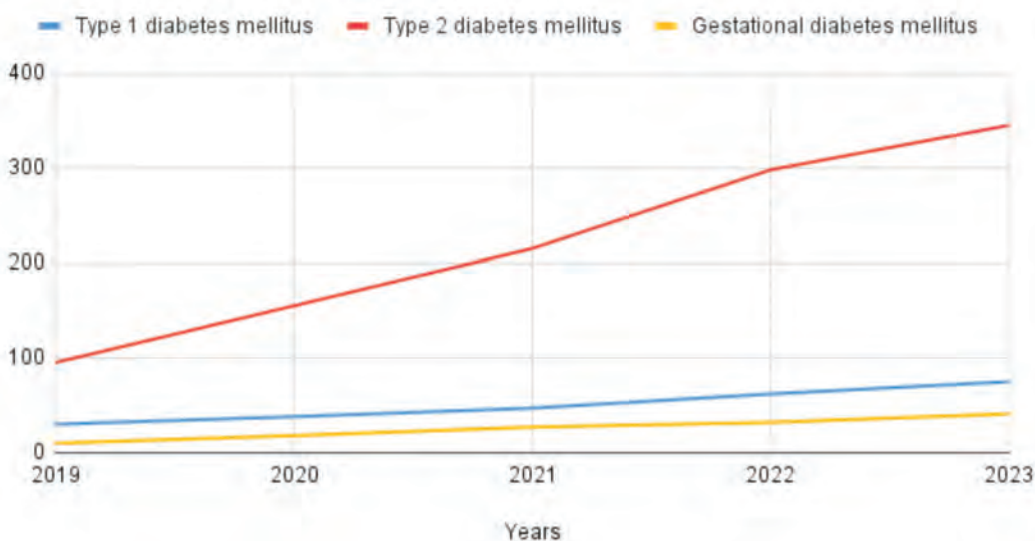

Figure 1 – Dynamics of the prevalence of diabetes mellitus per 1000 population,
Almaty, 2019-2023 yy.

The ECG results in patients with Type 2 diabetes show that the QRS interval moves to the left, the R indicator increases and the T indicator decreases. Cardiovascular diseases are more common among older men and smokers; also patients' behavior affects CVD [1]. In patients who have Type 2 diabetes for a long time, CVD is more common and the QTc interval is longer [2]. Patients with type 2 diabetes who also suffer from obesity, abdominal obesity, adult men and smokers develop myocardial ischemia and the ST segment changes [3]. In patients with Type 2 diabetes, smoking, albuminuria, hemoglobin, arterial hypertension and body weight indicators have an effect on changes in the Q, ST, T intervals of ECG [4-14]. In the study conducted by Holter monitor on a total of 104 patients with Type 1 and type 2 diabetes it was found that patients with Type 2 diabetes most commonly suffer from latent myocardial ischemia and silent heart ischemia than patients with Type 1 diabetes [5]. Another study with 237 patients with Type 2 diabetes, the vast majority of which were male, presented the results where the majority of patients suffer from silent heart ischemia [6]. Diabetes is the main risk

factor for CVD mortality. In patients with Type 2 diabetes mellitus, the QT interval increases according to the ECG result [7]. Patients with diabetes are more prone to diabetic peripheral neuropathy [8-15]. Various ECG myocardial infarction, ischemic disorders, left ventricular hypertrophy, atrial fibrillation are caused by Type 2 diabetes [9]. According to the study conducted in patients with Type 2 diabetes in the Amhara National Regional Public Hospitals of Ethiopia, ECG fluctuations were associated with excess weight, hypertension, duration of the disease, high income, high blood sugar on an empty stomach [10].

Taking previous research in consideration, it was found that the gender, age, duration of pain in patients with Type 2 diabetes and the possibility of the presence of cardiovascular diseases might influence the change in ECG, and there is an insufficient number of studies conducted on the population of Kazakhstan. The purpose of the study is to test Kazakhstan patients with Type 2 diabetes using ECG, taking into account individual characteristics.

Materials and Methods. 52 people with type 2 diabetes with an average age of 55 participated in the study. The experiment was held on Almaty citizens and the data about the patients was taken from the Almaty department of the "Republican Electronic Health Care Center". The data collected is shown in Table 1.

Table 1 – Data about the participants with type 2 diabetes

I	II	III	IV	V	VI	VII	VIII
female n = 20	40 < 50 n = 6	+n = 4 6	1 y < 5 y n = 15	+n = 18	+n = 3	lower n = 20	+n = 2 5
male n = 32	50 < 60 n = 27	-n = 6	5y < 10y n = 24	-n = 34	-n = 4 9	average n = 26	-n = 27
–	60 < 70 n =19	–	more than 10 years n = 18	–	–	higher n = 6	–

Number (n), present (+n), absent (-n). I, gender; II, age; III, overweight; IV, duration of illness; V, smoking habits; VI, early CVD; VII, income; VIII, presence of type 2 diabetes in parents.

The ECG signals were registered by the PCA 83G portable cardiac analyzer made by the former professor of Satbayev University K.A. Ozhikenov's students which is shown on Figure 2 [11-12].

PCA 83G is intended to carry out screening studies in order to diagnose and monitor heart conditions. A portable cardiac analyzer can be used on an active patient to diagnose the condition of the heart.

In a portable cardiodiagnostics system, a set of filters was used to change the relationship between their parameters depending on the signal-interference condition in the local parts of the filter to increase the efficiency of slowing down the interference in the electrocardiosignal and the resistance of ECG diagnostics systems to interference [13]. This principle of combining filters is called adaptive aggregation of filters (AAF). According to this principle, each local part of the signal (electrocardiosignal or its component) is processed by a separate filter.

To conduct this experiment, electrocardiosignals of the participants in the experiment were taken at the research center of the Department of robotics and automation tools of technology (Satbayev University) in Figure 3.

Figure 2 – Portable cardiac analyzer used in the experiment
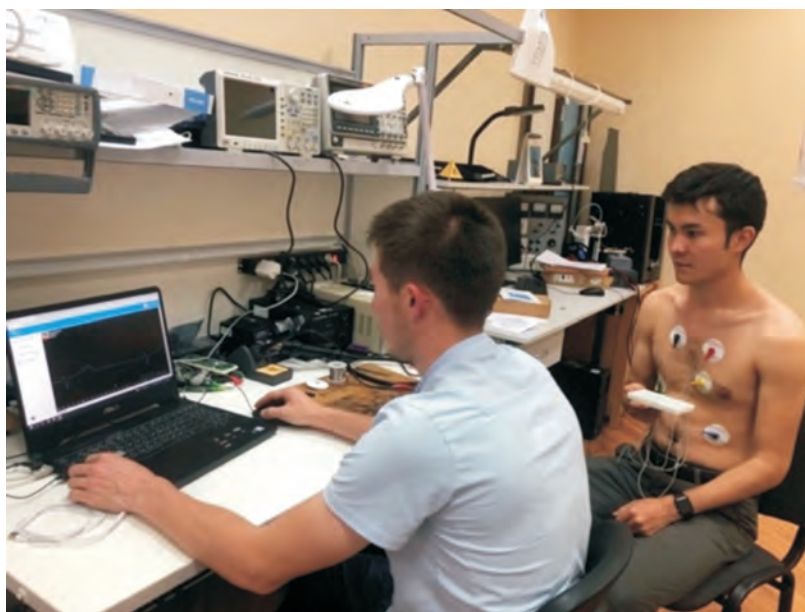

Figure 3 – Participant in an experiment with an ECG with one channel electrode

To compare the ECG results in patients with type 2 diabetes mellitus, a normal sinus rhythm was used in Figure 4, obtained from the educational and methodological complex of the Kislovodsk Medical College.
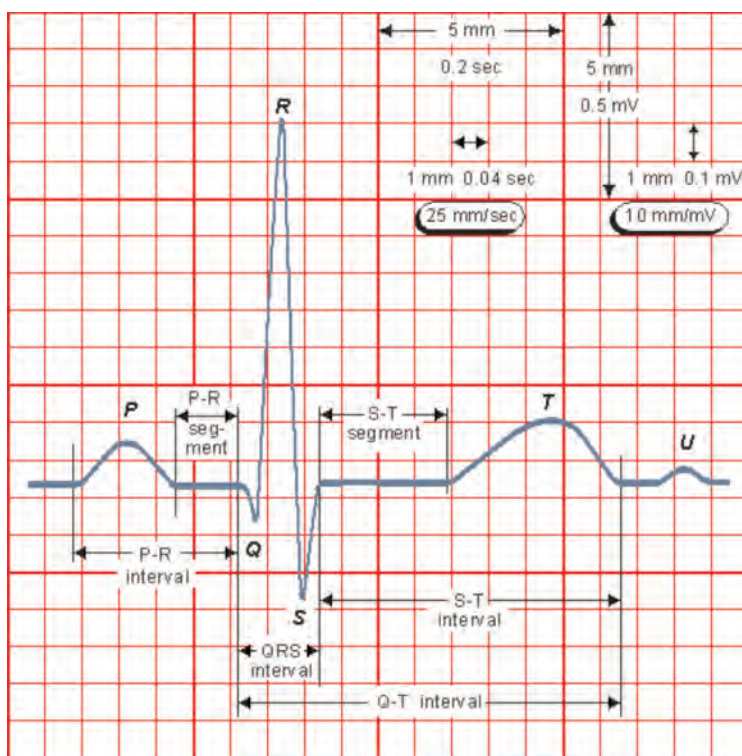
Figure 4 – Normal sinus rhythm

To compare the ECG results of the participants, a normal reading for adults and children with Type 2 diabetes shown in Table 2 was used (it was recommended by the American Diabetes Association), determining the sugar level with a traditional glucometer.

Table 2 – Normal indication for adults and children with type 2 diabetes

Time	Average indicator
On an empty stomach (before the meal)	80-130 mg/dl
1-2 hours after the meal	less than 180 mg/dl

Milligram/deciliter (mg/dl).

Results and Discussion. The study was conducted over two days. On the first day, the experiment was carried out on an empty stomach until 8:00 in the morning, and on the second day, the data was collected 2 hours after eating until 20.00 in the evening. Unlike previous research, in this study, participants were not given a glucose solution. Participants went through two different tests over two days. First, blood sugar levels were measured by glucometer after taking blood from the fingers of the participants, and then they had undergone the ECG procedure. The results of the experiment are summarized in Table 3.

Table 3 – The results of the experiment held in the morning on the first day and in the evening on the second day

	Participants to the experiment	The morning ECG results	The morning glucometer results	The evening ECG results	The evening glucometer results
	1	2	3	4	5
I	female	S, T, QTc, ST, QRS change (18%)	80-130 mg/dl (65%)	S, T, QTc, ST, QRSchange (52%)	180 mg/dl lower (35%)
	male	S, T, QTc, ST, QRS change (32%)	80-130 mg/dl(57%)	S, T, QTc, ST, QRSchange (66%)	180 mg/dl lower (22%)
II	40<50	S, T, QTc, ST, QRS change (15%)	80-130 mg/dl(87%)	S, T, QTc, ST, QRSchange (45%)	180 mg/dl lower (43%)
	50<60	S, T, QTc, ST, QRS change (28%)	80-130 mg/dl(68%)	S, T, QTc, ST, QRSchange (52%)	180 mg/dl lower (40%)
	60<70	S, T, QTc, ST, QRS change (34%)	80-130 mg/dl(57%)	S, T, QTc, ST, QRSchange (58%)	180 mg/dl lower (39%)
III	+n=46	S, T, QTc, ST, QRS change (26%)	80-130 mg/dl(55%)	S, T, QTc, ST, QRSchange (39%)	180 mg/dl lower (28%)
	−n=6	S, T, QTc, ST, QRS change (24%)	80-130 mg/dl(57%)	S, T, QTc, ST, QRSchange (38%)	180 mg/dl lower (29%)
IV	1 y < 5 y n=15	S, T, QTc, ST, QRS change (15%)	80-130 mg/dl(25%)	S, T, QTc, ST, QRSchange (37%)	180 mg/dl lower (65%)
	5 y < 10 y n=24	S, T, QTc, ST, QRS change (28%)	80-130 mg/dl(33%)	S, T, QTc, ST, QRSchange (42%)	180 mg/dl lower (53%)
	more than 10 years n=18	S, T, QTc, ST, QRS change (36%)	80-130 mg/dl(45%)S,	T, QTc, ST, QRSchange (54%)	180 mg/dl lower (35%)
V	+n=18	S, T, QTc, ST, QRS change (38%)	80-130 mg/dl(43%)	S, T, QTc, ST, QRSchange (51%)	180 mg/dl lower (36%)
	−n=34	S, T, QTc, ST, QRS change (25%)	80-130 mg/dl(55%)	S, T, QTc, ST, QRSchange (37%)	180 mg/dl lower (48%)
VI	+n=3	S, T, QTc, ST, QRS change (44%)	80-130 mg/dl(41%)	S, T, QTc, ST, QRSchange (54%)	180 mg/dl lower (36%)

Окончание таблицы 3

	1	2	3	4	5
	–n=49	S, T, QTc, ST, QRS change (36%)	80-130 mg/dl(47%)	S, T, QTc, ST, QRSchange (43%)	180 mg/dl lower (46%)
VII	lower n=20	S, T, QTc, ST, QRS change (24%)	80-130 mg/dl(50%)	S, T, QTc, ST, QRSchange (41%)	180 mg/dl lower (42%)
	average n=26	S, T, QTc, ST, QRS change (22%)	80-130 mg/dl(48%)	S, T, QTc, ST, QRSchange (38%)	180 mg/dl lower (44%)
	higher n=6	S, T, QTc, ST, QRS change (23%)	80-130 mg/dl(52%)	S, T, QTc, ST, QRSchange (38%)	180 mg/dl lower (44%)
VIII	+n=25	S, T, QTc, ST, QRS change (27%)	80-130 mg/dl(63%)	S, T, QTc, ST, QRSchange (42%)	180 mg/dl lower (35%)
	–n=27	S, T, QTc, ST, QRS change (24%)	80-130 mg/dl(61%)	S, T, QTc, ST, QRSchange (40%)	180 mg/dl lower (38%)

I, gender; II, age; III, overweight; IV, duration of illness; V, smoking habits; VI, early CVD; VII, income; VIII, presence of type 2 diabetes in parents.

According to the results obtained in the morning, the change in ECG intervals was higher in men compared to women by 14% (I), in participants aged 60<70 years by 19%, by 6% (II) compared to those aged 40<50, 60<70 years, by 2% (III) in overweight participants, by 21% for patients who are ill for more than 10 years compared to 8% (IV) of those who are ill for 1 year < 5 years, 5 years < 10 years, by 13% for smokers compared to non-smokers (V), in patients with early CVD by 8% (VI) compared to patients without CVD, by 2%, 1% for low-income compared to middle-income and high-income patients (VII), and by 3% in patients whose parents had Type 2 diabetes (VIII). And, according to the evening results, the change in ECG intervals in men compared to women was higher by 14% (I), in participants aged 60<70 years 13%, by 6% (II) compared to those aged 40<50, 60<70 years 13%, 6% (III) in overweight participants, for patients who are ill for more than 10 years by 17%, 12% (IV) compared to those who have had the disease for 1 year < 5 years, 5 years < 10 years, by 14% for smokers compared to non-smokers (V), patients with early CVD by 11% (VI) compared to patients without CVD, by 3% (VII) for low- income compared to middle-income and high-income people, and by 2% for people whose parents also suffered from Type 2 diabetes (VIII).

Conclusion. In conclusion, the research results show that the S, T, QTc, ST, QRS intervals in ECG changed more for male rather than female patients, adults over sixty years of age, smokers, and participants with early CVDs. Although, the participants' income, weight gain, and presence of diabetes in their parents did not have a significant impact on changes in ECG intervals, we assume that these factors might have more influence on the

occurrence of diabetes in patients. In the future we plan to do research to determine whether physical activity of the body, the types of temperament, and mental state affects the rise in blood sugar levels and the occurrence of CVD.

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2 ТИПТІ ҚАНТ ДИАБЕТІМЕН АУЫРАТЫН НАУҚАСТАРДАҒЫ ЭЛЕКТРОКАРДИОГРАФИЯЛЫҚ ӨЗГЕРІСТЕРДІ ЗЕРТТЕУ

Қант диабеті ерте I ғасырдан бері белгілі, түрлері және ауыратындар саны көп жаһандық мәселелердің біріне айналған ауру. Ал 2 типті қант диабеті көптеген факторлардың әсерінен пайда болатын, қант диабетінің кеңінен таралған бір түрі. Біздің зерттеудің жалпы мақсаты 2 типті қант диабеті бар науқастардың қант деңгейін инфекция тудырмайтын, инвазивті емес әдіс электрокардиограмма (ЭКГ) арқылы анықтау. Зерттеу екі күнге созылды. Бірінші күні таңғы 8:00-ге дейін аш қарынға, ал екінші күні тамақтанғаннан кейін екі сағаттан соң кешкі 20:00-ге дейін эксперимент жүргізілді. Зерттеуде 2 типті қант диабеті бар 20 әйел және 32 ер адамның қант деңгейі электрокардиограммамен және нәтижелерді салыстыру мақсатында глюкомет-рмен анықталды. 2 типті қант диабеті бар науқастардың жынысы, жасы, артық салмағының болуы, ауыру ұзақтығы, темекі шегу әдеті, табыс мөлшері, қант диабетінің (ҚД) ата-насында болуы, ерте жүрек-қан тамырлар ауруларының (ЖҚА) болуы туралы деректер қатар алынды. Зерттеу нәтижесі бойынша 2 типті қант диабетімен ауыратын науқастарда ЭКГ-ның S, T, ST, QTc, QRS аралықтары өзгеріске ұшырайтыны және таңғы уақытқа қарағанда кешкі уақытта қант деңгейінің мөлшері жоғарырақ болатыны анықталды.

Түйін сөздер: *2 типті қант диабеті, электрокардиография, электрокардиосигнал, инвазивті емес әдіс, кардиоанализатор.*

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ИССЛЕДОВАНИЕ ЭЛЕКТРОКАРДИОГРАФИЧЕСКИХ ИЗМЕНЕНИЙ У БОЛЬНЫХ САХАРНЫМ ДИАБЕТОМ 2 ТИПА

Диабет, который известен с начала I века, является болезнью с большим количеством типов и поражающих людей, и он стал одной из глобальных проблем. Из них диабет 2 типа, который имеет множество влияющих факторов, является одним из наиболее распространенных типов диабета. Целью нашего исследования является определение уровня сахара у пациентов с сахарным диабетом 2 типа с помощью неинвазивного метода, который не вызывает инфекций, то есть электрокардиограммы (ЭКГ). Исследование длилось два дня. Эксперимент состоял из двух частей: одна проводилась натощак до 8:00 в первый день, а вторая - через два часа после еды на второй день до 20:00. Чтобы сравнить результаты, уровень сахара у 20 женщин и 32 мужчин с сахарным диабетом 2 типа был определен с помощью электрокардиограммы и глюкометра. Соответствующим образом были собраны данные о поле, возрасте, избыточном весе, продолжительности болезни, привычках к курению, доходах, диабете в анамнезе родителей, ранних стадиях сердечно-сосудистых заболеваний (ССЗ). Результаты исследования показывают, что у пациентов с сахарным диабетом 2 типа изменяются интервалы S, T, ST, QTc, QRS на электрокардиограмме (ЭКГ), а уровень сахара вечером выше, чем утром.

Ключевые слова: *сахарный диабет 2 типа, электрокардиография, электрокардиосигнал, неинвазивный метод, кардиоанализатор.*