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Possibilities of the Akabane test for thermopuncture monitoring of B-lipoproteins in diabetes mellitus.

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Abstract

Background. The problem of dyslipidemia in diabetes is very relevant, since most of these patients die from atherosclerotic lesions and arterial thrombosis due to lipid metabolism disorders. At the same time, there is currently only invasive assessment of blood lipids, which makes their real monitoring very problematic. The hypothesis of the study was to identify the relationships between the level of B-lipoproteins, as one of the most atherogenic LDL, and the thresholds of thermal pain sensitivity (TPS) according to the Akabane test at standard diagnostic points of the acupuncture channels (AC). The presence of such relationships provides a basis for assessing LDL by calculation method using TPS.

Methods/Design: To identify the relationships between the TPS of acupuncture channels and the concentration of B-lipoproteins in the blood, 85 patients with type 1 diabetes (11 men and 74 women) and 115 patients with type 2 diabetes (37 men and 78 women) were examined. For comparison, the group of healthy subjects consisted of 57 men aged 26 to 35 years. All patients underwent blood lipid biochemistry and the Akabane test with TPS assessment, which allowed for the analysis of relationships.

Results. Various methods of statistical analysis revealed reliable relationships between the TPS of certain AC and the level of B-lipoproteins in the blood both in normal conditions and in type 1 and 2 diabetes in men and women. Moreover, these relationships mainly concerned the same AC, which reflect the work of various organs and systems usually involved in lipid metabolism, with the exception of some gender characteristics in diabetes. At the same time, the assessment of the degree of pathological disorders of B-lipoproteins by TPS may be based on the principle of their symmetry violation, which allows for the gradation of lipid metabolism disorders by severity on new principles, by calculation based on individual or group "Training measurements"

Conclusion. Thus, based on the results of the TPS assessment at certain diagnostic points of the TCM, the proposed concept and the results obtained in this study, it becomes possible to non-invasively assess various types of lipid metabolism by calculating non-invasively using neural networks and AI on large clustered samples, which will improve the accuracy of the assessment. Further development of this technology will allow the creation of a new generation of autonomous diagnostic devices for monitoring lipid metabolism on new principles.

Key words:

B-lipoproteins

diabetes mellitus type 1-2

Akabane test

metabolic disorders

acupuncture channels

Abbreviation

AC- acupuncture channels

TCM -Traditional Chinese Medicine

TPS- thresholds of thermal pain sensitivity

T1D- diabetes mellitus type 1

T2D- diabetes mellitus type 2

BAP- biological active points

1. Introduction

According to statistics, up to 97% of patients with insulin resistance have abnormal fat metabolism [1-3].

One of the main factors increasing the cardiovascular risk associated with diabetes is dyslipidemia, which includes abnormalities in all fractions of lipoproteins, including low-density lipoproteins (LDL), which include B-lipoproteins and cholesterol [4-8].

They are also called “bad cholesterol”, since they often remain on the vascular walls, which leads to the appearance of unstable cholesterol “killer plaques” on the vessels (9). Beta lipoproteins are the main transport form of cholesterol. Normally, 80% of them are formed in the liver and 20% come with food, forming a shell of drop-shaped formations - chylomicrons, inside which there is cholesterol, which is thus transported in the blood. Cholesterol itself is not soluble in water. Therefore, pure cholesterol cannot travel independently through blood plasma. For transportation, synthesized sterol binds to very low or low density lipoproteins (LDL). Results from the United Kingdom Prospective Diabetes Study (UKPDS) showed that intensive glycemic control significantly reduces the risk of microvascular complications of diabetes, but does not have a significant effect on macrovascular complications and overall mortality [10]. The UKPDS study data also demonstrate the existence of a relationship between the risk of coronary heart disease and LDL cholesterol concentration in patients with type 2 diabetes: an increase in LDL cholesterol concentration by 1 mmol/l is accompanied by a 1.57-fold increase in the risk of developing coronary heart disease [11]. Each of these dyslipidemia features is associated with an increased risk of cardiovascular diseases [12,13]. Therefore, in diabetes, it is extremely important to monitor lipid metabolism, which is now carried out using complex invasive biochemical blood tests. Therefore, we began to look for alternative options for non-invasive assessment of dyslipidemia on new principles, using the acupuncture channel system and their TPS indicators at diagnostic points as a sensor. Earlier, for example, we received clear data that in diabetes, these indicators reflect the blood glucose level [14-17], which, by analogy, gives hope for their reaction to blood lipids ... In this study, we did not set the task of a detailed study of all the nuances of lipid metabolism in diabetes. We wanted to get an answer - whether the TPS channel parameters reflect changes in lipid metabolism or not. If such connections can be traced, then the possibility of easy control of lipoprotein levels by calculation according to the Akabane thermopuncture test appears. For a preliminary assessment of the results, we present data on the connections with acupuncture channels mainly only for cholesterol and B-lipoproteins in the blood, as the most dangerous in diabetes.

2. Materials and methods.

The studies were conducted in a specialized endocrinology department in the morning on an empty stomach, by taking blood from a vein with subsequent Akabane test. A total of 85 patients with type 1 diabetes (11 men and 74 women) and 115 patients with type 2 diabetes (37 men and 78 women) were examined. The norm is 57 people, these are men from 26 to 35 years old.

To quantitatively evaluate a channel's activity level in TCM, the so-called "sacrificial stick" test was used in ancient times in China. This test involved a burning sandal stick that was brought in proximity to points at the tips of every finger and toe until the first sensation of pain. At each point, the pulse rate before pain was first felt, was measured. If the number of pulse beats was lower than the average one for all the channels, it proved the hyperactivity of an acupuncture channel and its corresponding organ. Conversely, when the rate was higher, it represented the inactivity of a channel and its corresponding organ. This test was described by the Japanese doctor Koben Akabane in 1956. Since then, the test has carried his name [18].

According to classical Oriental literature as well as according to our study results [19- 21], the following channels have different regulatory functions:

LU- lungs channel, connected with the function of lungs and tissue breathing.

Li- large intestine channel, connected with the large intestine function and its microbe flora, it participates in the regulation of arterial pressure, biochemical blood indices.

PC - pericardium channel, connected with the cardiac muscle trophicity and its structure. In addition, it is connected to muscular activity, arterial blood pressure levels and emotions.

TE- triple heater channel, connected to the central and peripheral hemodynamic, and with body energy consumption. In addition, it regulates the hormones in the body, thyroid and hypophysis.

HT - heart channel, regulates the cardiac rhythm, body’s physical strength

Si - small intestine channel, connected to the electrolytic balance and food digestion.

SP- spleen-pancreas channel is connected to the pancreas and immunity.

LR- liver channel is connected to liver function and central nervous system, stress levels

St- stomach channel is connected to the digestion function.

GB- channel of the gallbladder is connected to the digestion function and peripheral nervous system.

Ki- kidney channel is connected to the kidney function and the adrenal glands, controls the total supply of energy in the body and its redistribution.

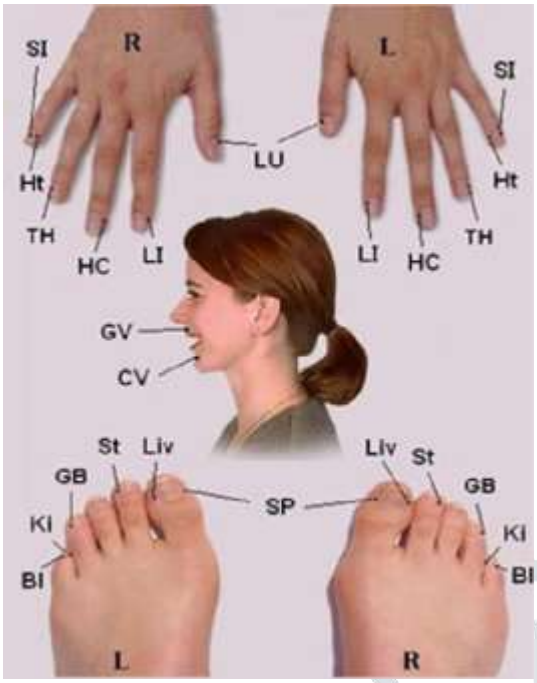
BL- urinary bladder channel is connected to the urogenital system, its functions and its related hormones, it reflects the state of vertebrae column as well.

CV -channel, reflects the general accumulation of energy in the body and anabolic processes

GV- channel, reflects the general energy expenditure and catabolic processes

Each channel consists of the left (l) and the right (r) branch between which normal symmetrical activity balance is maintained. TPS is our bodies’ basic reactive system; it is as significant as important indicators such as body temperature, as it gives a very clear representation of functional and psycho-physiological profiles. Their topography is shown in Fig.1

Fig.1.Topography of acupuncture points, used for evaluation of the AC in Akabane test.



This test measures the pain thresholds in temperature sensitivity (TPS) when heat is applied to the "entrance-exit" points of each channel (LU11, LII1, PC9, TE1, HT9, SI1, SP1, LR1, ST45, GB44, KI1, and BL67) by applying an impulse light-emitting diode (LED) non-coherent infrared radiation (IR)-light onto the skin (f = 1 Hz, λ = 920 nM), recording the total energy expenditure in joules. Each impulse radiates 0.07 joules of thermal energy. These measurements were carried out using a certified device – "ChiMaster", invented by the author of this paper.

The analysis of the relationship between biometrical indicators and AC was carried out using correlations (Pearson and Spearman coefficients), multiple regression analysis and multifactorial ANOVA analysis. Mann-Whitney test were used for paired comparisons. Statistical decisions were made at the 5% ($p \leq 0.05$). significant level ($p \leq 0.05$). We used the SPSS software package version 15.

3.Results

B-lipoprotein Study in the Norm

In the norm, B-lipoproteins perform the transport function of transferring cholesterol from the liver throughout the body. Table 1, which summarizes the data, presents only significant correlations at the level of 12-24 AC. They are traced mainly only by LDL by 3 channels: these are both branches of the AK of the large intestine, the PC channel with its left branch and the heart channel on the right and by the sum of its two branches. For the remaining indicators, a single trend is observed for the relationship of the pericardial channel ($r = .239$; $p = .074$) with the atherogenicity index and the left branch of the BL channel ($r = -.26$; $p = .049$) with LDL. At the same time, the PC channel reflects the participation of muscle mass in physical activity. Therefore, this relationship is quite logical. The relationship of the left branch of the BL with the (-) sign is also logical, since it reflects the sexual hormonal background and sexual activity of men. The higher the value of the left branch of this AC, which is usually associated with high sexual activity [19,20], the lower the LDL value, probably due to the participation of these lipoproteins in the process of spermatogenesis. Thus, it turns out that sex is very useful for men to reduce the level of harmful lipids that affect the vascular wall.

Table 1. Significant correlations of channels with LDL indicators in men in the norm.

C	B-lipoproteins r	

Also, in healthy men, the R/L channel ratio showed a significant correlation ($r = .266$; $p = .046$), the PC channel with the atherogenic index and the level of high-density cholesterol ($r = .267$; $p = .045$).

Results of the study of B-lipoproteins in diabetes.

Fig. 2 shows the distribution of B-lipoprotein indices (in conventional units) in men and women. Fig. 3 shows their height-weight indices and correlation fields for these indices (Fig. 4). In general, the correlation between B-lipoproteins and the height-weight index is very weak (Rsq=0.05 and 0.01). To create contrasting groups, the B-lipoprotein data were divided into three groups according to their increasing concentration: 1) - beta_lp<=25 2) - 25<beta lp<=60, 3)-beta_lp>60;

Fig. 2. Diagram of B-lipoprotein indicators in diabetes in conventional units.

where the norm is 25-50 units) in men and women.

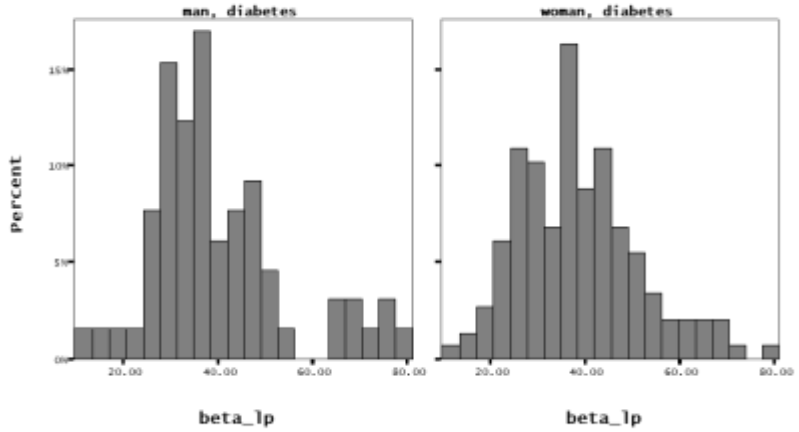


Fig. 3. Diagram of the distribution of height-weight index indicators in men and women with diabetes.

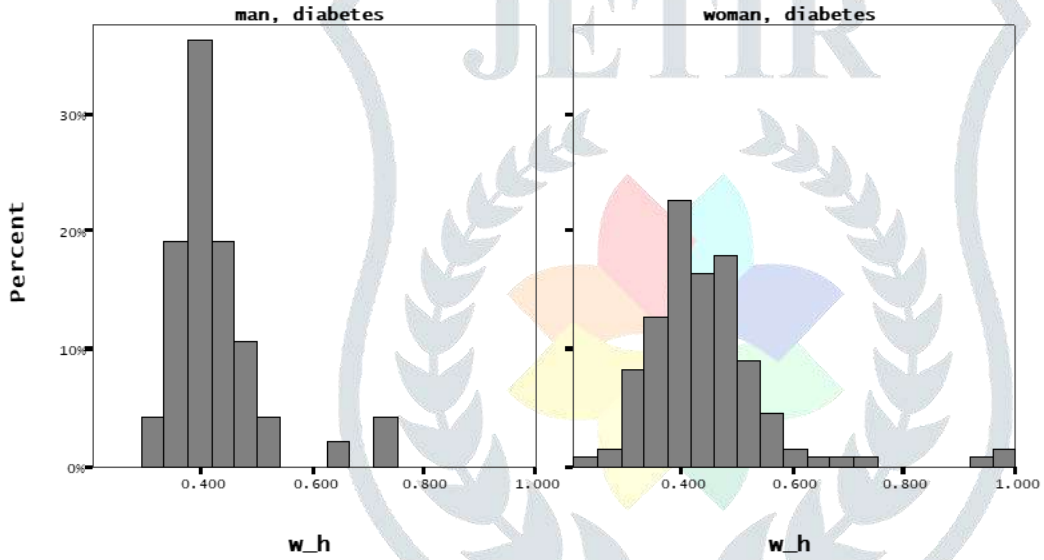


Fig. 4. Correlation fields of relationships between the level of B-lipoproteins and the height-weight index in men and women with diabetes according to linear regression data.

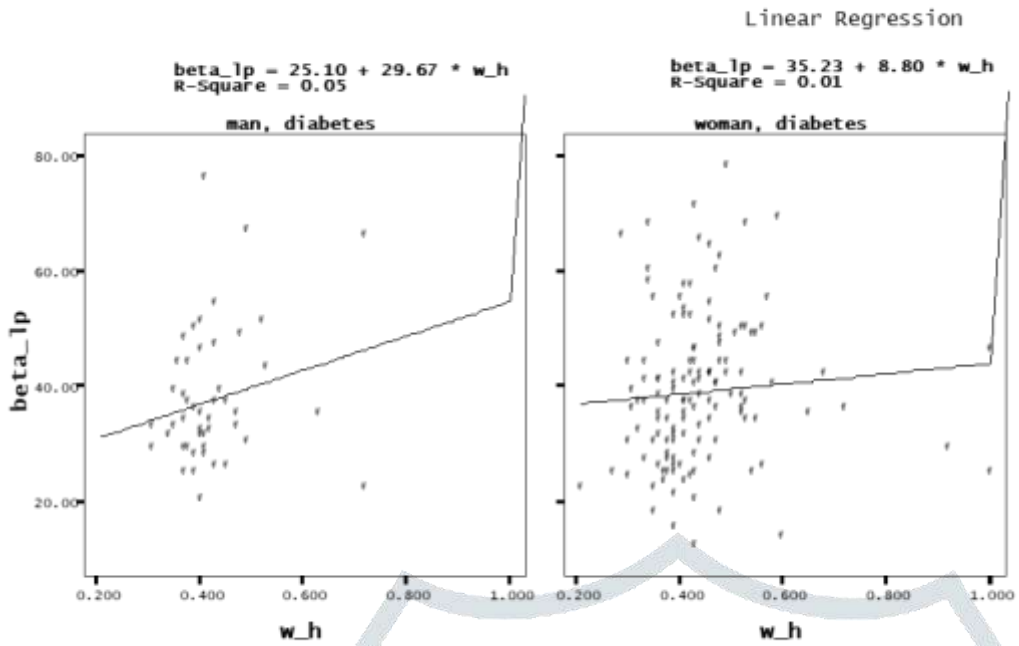


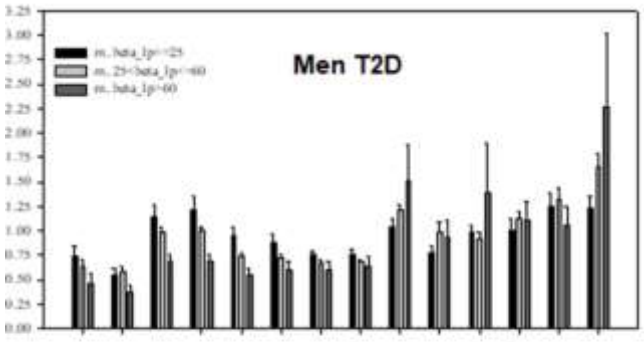
Fig. 5 shows the profiles of the 14 channels scaled to the average value of the TPS in men and women with T2D when divided into 3 groups by the level of B-lipoproteins.

In men, for a number of AC (CV, LU, LI, PC, TE, SI), a clear decrease in TPS below the average values (1.0) is visually observed, reflecting the hyperactivity of the organs associated with these ACs along with an increase in the level of B-lipoproteins in the blood. This pattern is also confirmed by the data of correlation analysis for 26 AC at the level of their left and right branches LUr (r = -. 336; p = .006), LUl (r = -. 414; p = .001), LIr (r = -. 492; p = .0001), LIl (r = -. 240; p = .054), PCr (r = -. 483; p = .0001), PCl (r = -. 356; p = .004), TEr (r = -. 335; p = .006). In two channels, by the sum of this TPS from two branches - SP (r = +. 225; p = .04) and BL, an inverse linear pattern is visually traced, when with an increase in the TPS indicators above the average, reflecting the hypofunction of these systems - the concentration of B-lipoproteins in the blood increases. However, according to the correlation analysis, it is not statistically confirmed.

In women with T2D at the level of 14 AK, a similar pattern is visually traced only by SP and LR. According to the correlation analysis, significant relationships are also observed with both branches of the pulmonary AC: LUr (r = -. 233; p = . 036) and LUl (r = -. 229; p = . 04). Although such a connection is not visually visible. In addition, as was shown earlier, hyperactivity of the pulmonary AC gives a decrease in the level of glycemia [15-17], which also likely affects the decrease in LDL.

Based on these data, it can be assumed in men and women in general that: 1) physical activity associated with increased pulmonary ventilation and activation of AC, reflecting the work of the cardiovascular system, contributes to a significant decrease in the level of B-lipoproteins, especially in men. 2) The microbiota of the large intestine also has a significant effect on lipoproteins, especially in men. 3) Another important pattern is observed in men - the higher the level of B-lipoproteins, the higher the AC-BL value for the sum of two branches. The TPS of the BL channel reflects the sex hormonal background and sexual activity. Therefore, hypofunction of this system with indicators greater than 1.0 leads to an increase in LDL, which is illustrated by this graph. But it should also be taken into account that AC-BL directly depends on the state of the microbiota of the large intestine, which is reflected in the PC of the LI channel. 4) In women, hypofunction of the pancreas and liver has an important effect on the growth of B-lipoproteins, which is traced based on the growth of their AC -TPS above the average values of 1.0.

Fig.5. Profiles of 14 channels, scaled by the average value of the TPS depending on three gradations of B-lipoproteins.



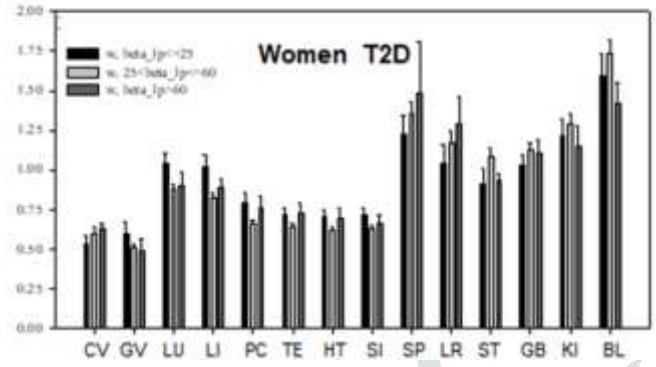
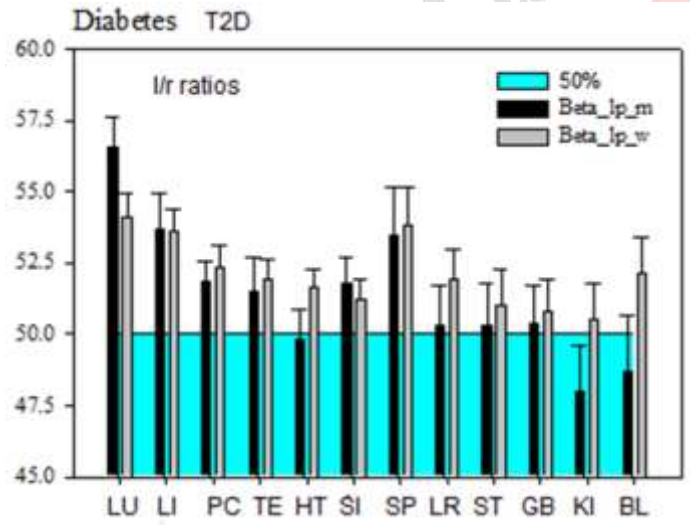


Fig.6. Average values of the proportion of TPS by the R/L ratio for 12 channels in men and women depending on the level of B-lipoproteins in T2D.



where 50% = symmetry of the right and left branches of the AC. Indicators over 50% reflect the growth of the right branches of the AC, and indicators below 50% - the predominance of the left branches in this proportion.

In our practice, we often use the ratios of the TPS indices of the right and left branches of the AC as one of the most informative indices of metabolic disorders at the level of a specific organ. The right branch in the channel reflects the level of its anabolic processes, and the left one reflects the level of catabolic processes, and normally their ratio is close to 1.0 [17]. Fig.6 shows a diagram of average values with variation ranges in the R/L ratios at the level of 12 channels in men and women depending on the level of B-lipoproteins. There is a certain difference in the PC profiles, especially for BL and LU. In men, the right branch of the AC of the lungs is significantly larger than in women, which is probably due to more significant physical activity and increased oxygenation. The situation is reversed on the BL channel, here the left branch in men generally prevails over the right one, so the total indicator of connections turned out to be below average, but with a wide range of values. This situation is more typical of male dyshormanosis. The graph shows that the maximum spread (deviation) of the PC parameters is noted on Ak-BL, SP and ST, which shows the compensation mechanisms in T2D conditions through these systems.

Table 2 shows the significance levels when checking the effect of B-lipoproteins on the TPS channels in T2D. In men, there are reliable dependencies for Lul, LIr, PCr and Ter. In women - only for PCr, which reflects blood circulation in the myocardium. Therefore, these disorders in the trophism of the heart muscle in dyslipidemia are characteristic of both men and women.

Table 2. The significance of TPS channels in men and women in T2D for single-factor comparisons in multifactorial ANOVA analysis.

Factor: B-lipoprotein level. Factor gradations: 1) - beta_lp <= 25, 2) - 25 <beta <= 60, 3) -beta lp> 60

AC	Men	Women
LUr	.081+	.093+
LUl	.008*	.270
LIr	.002*	.069+
LIl	.292	.069+
PCr	.003*	
PCl	.074+	
TEr	.030*	
TEl	.263	
HTl	.799	

Results of stepwise linear regression analysis.

T1D. The results of the regression analysis of the dependencies of the TPS indicators of 14 main channels by the sum of their left and right branches on the level of B-lipoproteins in women with T1D are presented in Table 3.

Table 3. Model of dependencies of the TPS indicators for 14 AC on the level of B-lipoproteins in women with T1D.

Independent variable	coefficient	std. error	t-value	sig.level
CONSTANT	38.591429	6.015548	6.4153	0.0000
CV	9.581345	4.940951	1.9392	0.0567
BL	0.132658	1.21207	0.1094	0.9132
GV	-16.327724	6.728296	-2.4267	0.0179
LU	-18.769301	4.972396	-3.7747	0.0003
TE	23.915774	6.950032	3.4411	0.0010

R-SQ. (ADJ.) = 0.187; SE=10.222; MAE= 7.780; DurbWat= 1.899; 56 observations

In this model, it is noteworthy that the unpaired channels CV and GV have different signs of dependence with lipoproteins, which corresponds to their functional features: according to TCM, the CV channel reflects the total accumulation, and GV - energy expenditure in the body. The main dependencies are traced with the LU and TE channels, which confirms the previous data. Significant dependencies with TE can be explained by the influence of thyroid hormones that control AC-TE. In general, in women with T1D, the situation with the formation of B-lipoproteins coincides with T2D.

Table 4 presents a model of regression dependencies for T1D already at the level of 26 AC, which provides more specific data on the connections with AC. Although in general the level of explainable variance is also small, some channels included in the model have a pronounced connection with the level of B-lipoproteins. The most pronounced dependence is observed with AK- TEr, LRl, LUr, as well as unpaired channels CV and GV, which, as before, have different signs of connections. It is also worth paying attention to the significant influence of the SPl channel on the metabolism of B-lipoproteins. This AC has a negative sign of influence, therefore, the higher its TPS, the lower the concentration of B-lipoproteins will be. In this dependence, everything is logical, since the growth of the left branch of the PC reflects the presence of hypoglycemia [14,15,23] in which lipid metabolism disorders will be minimal. The left branch of this AC is also affected by insulin injections [22,24]. The role of other AC - LU, LI, LR was also discussed earlier.

Table 4. Model of dependencies of 26 indicators of TPS channels on the level of B-lipoproteins in women with T1D.

Independent variable	coefficient	std. error	t-value	sig.level
CONSTANT	40.469628	5.123279	7.8992	0.0000
CV	8.859467	4.765393	1.8591	0.0672
GV	-12.731415	6.035618	-2.1094	0.0385
LUr	-9.260499	3.567376	-2.5959	0.0115
SPl	-2.881335	1.482783	-1.9432	0.0560
LIr	-4.294811	3.268648	-1.3139	0.1932

LRl	3.122917	1.697229	1.8400	0.0700
TEr	15.736298	5.514038	2.8539	0.0057

R-SQ. (ADJ.) = 0.185; SE= 10.132; MAE= 7.433; DurbWat= 2.031; 56 observations

Type 2 diabetes mellitus

T2D. In women with type 2 diabetes mellitus (Table 5), no reliable dependencies of B-lipoproteins with AC were found. The most significant (p=.007) dependency is observed with the BMI indicator, which we added for contrast. Thus, in this group, unlike T1D, changes in body weight lead to a significant disruption of lipid metabolism and B-lipoproteins in particular. The CV and GV channels were also included in the model with different signs, which again confirms their opposite effect on the production of B-lipoproteins. An increase in the TPS channel GV indicators reduces the level of B-lipoproteins in the blood, and an increase in the CV indicators, on the contrary, increases their concentration. This dependence can be used, for example, for a non-invasive express assessment of the situation by the ratio of the sensitivity thresholds of CV/GV. If this proportion is less than 1.0, this means that at the moment B-lipoproteins are decreasing. In this way, it is possible to track the effect of food, physical activity, etc. on lipid metabolism at the individual level.

Table 5. Model of dependencies of 14 AC and BMI indicators on the level of B-lipoproteins in women with T2D.

Independent variable	coefficient	std. error	t-value	sig.level
CONSTANT	43.644389	11.20832	3.8939	0.0003
CV	3.843576	7.511151	0.5117	0.6110
GV	-6.086552	9.008499	-0.6756	0.5022
BMI	26.51496	9.51683	2.7861	**0.0074**
LI	-8.359275	6.59387	-1.2677	0.2104
ST	-2.107101	4.115572	-0.5120	0.6108
BL	-1.229487	2.445534	-0.5027	0.6172

R-SQ. (ADJ.) = 0.084; SE=13.037; MAE= 9.232; DurbWat= 2.380; 60 observations

In women with type 2 diabetes mellitus, at the level of 24 branches of the canal, only the left branch of the AC of the colon has a tendency (p = .069) to depend on the level of B-lipoproteins. This once again confirms the important role of microbiota in lipid metabolism.

In men with type 2 diabetes Table 6 shows a selection of only reliable dependencies at the level of 24 and 12 channels on the level of B-lipoproteins in the blood.

Table 6. Final dependencies of PC at the level of 24 and 12 channels on the level of β-lipoproteins in T2D in men.

AC	Men T2D		
		Variation	
LUr			
LUl			
LIr			
PCr			
PCl			
Er			
LU			
LI			
P			
S			

** - Sig. - the significance of the angle of inclination.*

Here the regression coefficients of the relationship are small in absolute value, but in general this regression variant gave higher dependencies compared to women. In general, the set of channels reflecting the level of B-lipoproteins repeats the connections shown in men earlier with T1D: lungs, large intestine, pericardium, triple heater and pancreas. This means a largely unified mechanism for the formation of B-lipoproteins in men with both T1D and T2D. In men, as with T1D, there are significantly more such reliable connections with AK than in women. With the pancreatic channel, there is a dependence only on the sum of both branches of this channel.

Discussion

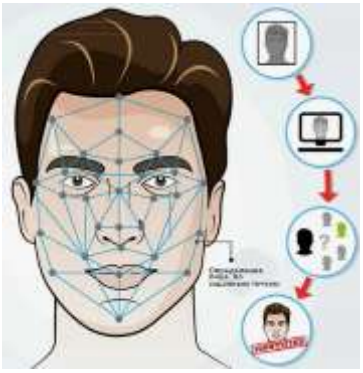
The results of the UKPDS (the United Kingdom Prospective Diabetes Study) showed that intensive glycemic control significantly reduces the risk of microvascular complications of diabetes, but does not have a significant effect on macrovascular complications and overall mortality [11]. Patients with type 2 diabetes are significantly more likely to develop acute myocardial infarction than individuals without diabetes, and the infarction size is usually larger, complications such as congestive heart failure and cardiogenic shock develop more often, and the long-term prognosis after surgical coronary revascularization is worse. After myocardial infarction, 40–50% of patients with diabetes die within the next five years. Therefore, in diabetes, it becomes extremely important to control lipid metabolism through complex biochemical studies.

However, in practice, such control is quite complicated and requires frequent and very expensive invasive studies, which is a huge obstacle to effective monitoring of these patients.

In this regard, we attempted to solve this problem using other principles described in this article and received the first positive result. As the results of this study show, the AC system in the thresholds of their temperature sensitivity really reflects the level of B-lipoproteins in the blood and is able to identify those organs and systems that are really involved in fat metabolism, which gives grounds for its active use in monitoring patients with diabetes, as well as for targeted correction of these disorders.

The basis for our solution was the ancient Akabane test with the assessment of TPS in certain diagnostic BAPs, which were determined in practice hundreds of years ago and have shown their informativeness in modern medicine for assessing the activity of various organs and systems through AC [25-27]. In fact, there are many normally symmetrical cluster structures on the human body at the AC level that determine the activity of various organs and systems with vertices in the form of BAPs, the TPS of which reflects the functional activity of various organs and systems [17,28]. In this case, the left and right BAPs at the AC level of each organ reflect the functional activity of the opposite regulatory subsystems. For example, at the AC of the pancreas, the TPS of the right point reflects the activity of B-cells that produce insulin and reduce the level of glycemia, and the left one reflects the activity of A-cells that produce counter-insular hormone that increases the level of glycemia, which is important for glycemia control in diabetes mellitus [17,29]. In this case, the violation of the symmetry of the TPS at these points from different sides reflects a violation of glucose regulation in the form of hypo or hyperglycemia. All this makes the AC system a unique source of obtaining medical information and lays down new principles of non-invasive control of glycemia, as well as dyslipidemia, as its consequence. This principle is very similar to the principle of assessing a person's personality based on biometric systems, where 7 main reference points on the face are used - the distance between the pupils, nose, corners of the mouth and their relationships (Fig.7). Then, these indicators are compared with databases using neural networks and AI to identify analogues and establish a person's identity.

Fig.7. Biometric principle of personal recognition



This system provides an accuracy of assessment on neural networks of 97-98%. In our assessment, 26 reference points are used (Fig. 1), with the TPS, which, unlike the points on the face, can change, which reflects the different activity of the organs associated with them, but these changes are synchronized with the changes in all other TPS, which are part of this ensemble of clusters from certain AC. Thus, for example, after the "training sample" it is possible to assess various biochemical indicators with an acceptable accuracy [30], suitable, for example, for non-invasive home monitoring. At the same time, the AC system acts as a translator of information from the human body, since through it it is possible for the first time and effectively to assess the violation of symmetry in the body by the imbalance of the right and left TPS in the diagnostic BAPs of certain AK, as a fundamental factor in the development of pathology. This is the innovative essence of this approach, since the violation of symmetry at the level of individual organs and systems, except at the level of paired acupuncture channels, cannot be assessed. However, in practice, the use of this system is quite labor-intensive and requires additional knowledge in interpreting the results. Therefore, we are currently developing a pulse diagnostics system, where all information about the AC and their TPS is extracted from the pulse wave in the dynamics of observation (31). This innovative approach to creating a new source of medical information from the pulse wave gives hope for creating a whole class of devices operating on a new principle of obtaining a wide variety of medical information from the pulse wave, including fat metabolism, in a simple and convenient non-invasive way for millions of users in real time.

Conclusions.

The AC system at the TPS level of certain channels actually reflects changes in the concentration of B-lipoproteins in the blood, which allows it to be used as a new non-invasive source of obtaining information on fat metabolism, including diabetes.

Disclosure statement

The authors declare that they have no conflicts of interest and no financial interests related to the material of this manuscript.

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