ОРИГИНАЛЬНАЯ СТАТЬЯ

# STUDY OF THE EFFECT OF DEFICIENCY OF MICROELEMENTS ON CARBOHYDRATE METABOLISM

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ABSTRACT. The article describes experimental research of the impact of microelement`s deficiency on human carbohydrate metabolism. The studies were conducted in conditions of ecological-biogeochemical optimum and disaster. The level of Cu, Si, Se, Mn, Ca, Cr, Y, F, the level of leptin, the serum glucose level were evaluated in a similar diet, and the body mass index of the experiment `s participants was determined.

Correlation links between individual microelements and indicators of exchange have been revealed: leptin level, fasting glycaemia. The difference was noticed in body mass between researched persons in two groups.

Pre-diabetic changes in a significant number of people living in the disaster zone have been diagnosed. The hypothesis about the effect of the imbalance of macro- and microelements on the carbohydrate metabolism in the human body has been confirmed. An auxiliary method of correction of carbohydrate metabolism has been created (Edwards, Cusi, 2016).

KEYWORDS: microelements and leptin, carbohydrate metabolism, metabolic syndrome, micronutrient deficiency, microelements and glucose, inulin-rich product, new generation's nutrition.

## INTRODUCTION

Today worldwide there is a high prevalence of diabetes mellitus and, as its predictor, metabolic syndrome.

According to the WHO, the number of patients with insulin-resistant syndrome is 10–20% among persons over 30 years of age in developed countries.

In recent years, there has been a steady trend towards «rejuvenating» of this problem (The Global Report on Diabetes. WHO, 2016).

Metabolic syndrome includes several symptoms: central obesity, hypertension, a violation of carbohydrate metabolism (insulin resistance), violation of fat metabolism (dyslipidemia) and development of gout, fatty degeneration of the liver, erectile dysfunction, polycystic ovaries, and in the future the occurrence of such serious diseases as Cirrhosis of the liver, thrombosis, diabetic retinopathy, stroke of cerebral vessels, myocardial infarction.

One of the causes of the metabolic syndrome is non-compliance with the «healthy lifestyle». First of all, it concerns the wrong nutrition. The lack of dietary fiber in the diet, the use of a large number of simple sugars are triggering factors to the development of obesity (Tolmacheva, et al., 2016). Obesity is most common in the USA. According to official data, the number of Americans with this pathology is 33%. Obesity is registered in 26.5% of the population in Russia.

It is known about the existence of a leptin hormone regulating energy metabolism. It refers to adipokines and has an anorexigenic effect. It is noted that a decrease in leptin concentration in the serum leads to the development of obesity. At the same time, its concentration in the blood is sharply increased in people who are overweight. The use of exogenous leptin is ineffective.

In general, the imbalance of macro- and microelements has a direct effect on the metabolism in the body (Tolmacheva, 2011). We investigated the inhabitants of two contrast zones in the ecological and biogeochemical environment to prove this fact, to find correlation links and to choose methods for solving problems.

Experimental studies are based on the need to determine the difference in the state of the components of carbohydrate metabolism in conditions of ecological-biogeochemical optimum and disaster, to determine the correlation of the imbalance of some macro- and microelements and leptin, to determine

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the connections with the violation of carbohydrate metabolism (diagnosed by hyperglycemia and an increase in body mass index), and to create methods for its correction.

**Objective:** to study the effect of a deficiency of microelements on the development of insulin resistance and the state of carbohydrate metabolism in the human body.

## MATERIALS AND METHODS

Seventy randomly selected practically healthy residents of the two regions were surveyed who were divided into two groups: experimental and control.

Two groups of surveyed used identical foodstuffs during the experiment (the analysis was conducted in food diaries). The level of some microelements (Cu, Si, Se, Mn, Ca, Cr, Y, F), leptin level, serum glucose level was determined, the body mass index of the participants in the experiment was determined, and the dependence between the indicators obtained after proving the fact of practically identical diet.

Both groups of subjects were observed for 4 months, living in two contrasting birth and death zones. The experimental group lives in the zone of ecological and biogeochemical disaster in the village Altyshevo of the Alatyrskiy district, the control group lives in the zone of ecological and biogeochemical optimum in the village of Yantikovo of the Yantikovskiy district.

Determination of microelements levels in blood serum of practically healthy residents of two contrast zones in the ecological and biogeochemical environment was carried out with the help of the certified diagnostic laboratory «Invitro» due to the grant «Studying the influence of micro and macroelements deficiency on human reproductive health (state contract No. 11731p / 17196 dated 04/05/2013). Contracts No. 17196-02, No. 2321 GU2 / 2014 ext. № 0004403.

Determination of the body weight of residents of both regions, the calculation of the arithmetic mean value were carried out according to the formula

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

($\overline{X}$ – sample mean, $n$ – sample size, $X_i$ – $i$ sampling element).

## RESULTS OF THE STUDY AND THEIR DISCUSSION

The following results were obtained after taking samples of venous blood from both groups.

The Si content was significantly increased 1.5 times ($p < 0.01$) and the Cr content was decreased 3.5 times ($p < 0.05$) when determining the microelements composition of the blood serum from the ecological and biogeochemical disaster zone (Table 1).

The level`s increase was almost 2 times (6.9 ± 0.9 ng/ml and 3.66 ± 0.31 ng/ml, respectively, $p < 0.05$) in determining the level of leptin in people living in the disaster zone (Table 2).

Investigation of the correlation between hormones and microelements showed a strong feedback between the chromium level and hormone leptin ($r = –0.92$, $p < 0.05$). In addition, a direct communication was revealed between silicon and blood glucose level ($r = +0.84$, $p < 0.05$).

The difference in the level of fasting glycaemia was 15% in representatives of two contrast zones. It is noted that an increase in the fasting blood sugar level by 1.5 times is more frequent in people living in the disaster zone in the range of 5.5–6.0 mmol/l, this is the first sign of a violation of carbohydrate metabolism. This indicator can be regarded as reflecting pre-diabetic changes in the body.

*Table 1.* ***Mass concentrations of macro- and microelements in the blood serum of practically healthy residents from the compared ecological-biogeochemical zones***

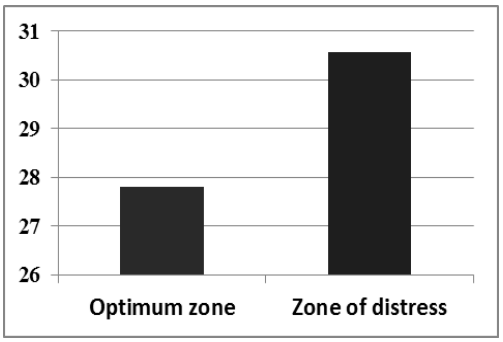
| Microelements | Optimum zone | Zone of distress | Reliability of differences, P |
|---|---|---|---|
| Cuprum, mg/kg | 0,673±0,025 | 0,665±0,02 | *NS* |
| Zinc, mg/kg | 1,03±0,051 | 1,121±0,09 | *NS* |
| Silicon, mg/kg | 1,307±0,035 | 1,9±0,08 | <0,01 |
| Selenium, mg/kg | 0,112±0,026 | 0,113±0,0023 | *NS* |
| Manganese, mg/kg | 0,004±0,0002 | 0,004±0,00042 | *NS* |
| Calcium, mg/kg | 93,855±2,179 | 106,266±4,23 | *NS* |
| Chromium, mg/kg | 0,006±0,0005 | 0,0017±0,0012 | <0,05 |
| Iodine, mg/l | 4,61±0,229 | 2,5±0,32 | *NS* |
| Fluorine, mg/l | 3,08±0,1207 | 2,0±0,12 | *NS* |

*Legend: NS* – «non statistica» lack of reliable differences.

*Table 2.* ***The level of leptin in the blood serum of practically healthy residents from the compared ecological-biogeochemical zones***

| Indicators, units | Zone of distress *M±m* | Optimum zone *M±m* | Limits of physiological norms |
|---|---|---|---|
| Leptin, ng/ml | 6,89±0,91* | 3,68±0,3 | For women: 0,5−13,8<br>For men: 1,1−27,6 |
| Fasting glycemia, mmol/l | 4,89±1,34 | 4,25±1,1 | 3,3 – 5,5 |

*Legend:* * – $p < 0.05$.




*Body weight of practically healthy inhabitants from the compared ecological-biogeochemical zones*

An increase in the average indicators of the disaster zone by 10% (27.8 kg/m$^2$ in a favorable environmentally-biogeochemical zone compared to 30.58 kg/m$^2$ in the disaster zone) was observed in the study of the body mass index of people living in contrasting ecological-biogeochemical zones (Figure).

Given the huge role of nutrition in the development of many chronic non-infectious and, in particular, endocrine pathologies, the formulation of an inulin-containing product has been developed that can be used for complex therapy of disorders of carbohydrate metabolism: metabolic syndrome, diabetes mellitus (invention patent No. RU 2577460 C1 «Composition for cereal bar»).

## CONCLUSION

The obtained data confirmed the hypothesis about the effect of the imbalance of macro- and microelements on carbohydrate metabolism in the human body. Data on the correlation of individual microelements and indicators of exchange can be used together with the developed recipe of an inulin-containing product in the prevention and treatment of pre-diabetes and type 2 diabetes mellitus.

It is necessary to continue working in the chosen direction to establish the mechanisms of interactions.

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# ИССЛЕДОВАНИЕ ВЛИЯНИЯ ДЕФИЦИТА МИКРОЭЛЕМЕНТОВ НА ОБМЕН УГЛЕВОДОВ

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РЕЗЮМЕ. В статье описывается экспериментальное исследование влияния дефицита микроэлементов на углеводный метаболизм у человека. Исследования проводились в условиях эколого-биогеохимического оптимума и в зоне экологического бедствия. У участников эксперимента при сходном питании оценивали содержание Cu, Si, Se, Mn, Ca, Cr, Y, F, уровень лептина, уровень глюкозы в сыворотке крови и определяли индекс массы тела. Выявлены корреляционные связи между отдельными микроэлементами и индикаторами обмена: уровнем лептина, гликемией натощак. Между исследованными добровольцами в двух группах наблюдалась разница в массе тела. Были диагностированы преддиабетические изменения у значительного числа людей, проживающих в зоне бедствия. Подтверждена гипотеза о влиянии дисбаланса макро- и микроэлементов на углеводный обмен в организме человека. Ранее был создан вспомогательный метод коррекции углеводного обмена (Edwards, Cusi, 2016).

КЛЮЧЕВЫЕ СЛОВА: микроэлементы и лептин, углеводный обмен, метаболический синдром, дефицит микронутриентов, микроэлементы и глюкоза, богатые инулином продукты, питание нового поколения.