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## Correction of food habits in patients with carbohydrate metabolism disorders

**Summary.** According to the International Diabetes Federation, the prevalence of prediabetes is approximately 10% among the adult population in Ukraine. According to many studies, prediabetes is observed in every second obese patient; and in the future, prediabetes can turn into type 2 diabetes mellitus (DM). Therefore, early detection of carbohydrate metabolism disorders is very important; implementation of recommendations regarding lifestyle changes, use of modern medicinal products to prevent type 2 diabetes and cardiovascular diseases. In recent years, more and more attention has been paid to dietary fiber (DF) as an integral component of a healthy diet. They contribute to the prevention of obesity, metabolic syndrome and adverse changes in the intestines, and help to the growth of the population of beneficial bacteria in the intestines as well. That is why nutritionists recommend obese people to include dietary fibers in their diet. One of the most well-known dietary fiber is psyllium, which is obtained from the husk of plantain seeds (*Plantago ovata*). Numerous studies show that psyllium has a positive effect on the functioning of many organs and systems, including the work of the pancreas, intestines and heart muscle. Also, psyllium provides a reduction in the level of glucose and cholesterol and is an effective means of losing weight for people who have excess body weight. The plant complex Fibolex® contains dietary fibers (psyllium and natural wheat fibers) and green tea extract. Due to the combined herbal composition, Fibolex® complex can be used for people with obesity, prediabetes, metabolic syndrome, type 2 diabetes mellitus and other metabolic disorders in order to correct food habits to improve the indicators of carbohydrate and lipid metabolism.

**Keywords:** prediabetes; obesity; carbohydrate metabolism disorder; dietary fiber; psyllium; Fibolex®

Impaired glucose tolerance (IGT) and impaired fasting glycemia (IFG) are early carbohydrate metabolism disorders, the prevalence of which constantly increases both in Ukraine and throughout the world [1]. Such conditions are interpreted as prediabetes and subsequently lead to type 2 diabetes mellitus (DM) and cardiovascular complications [1, 2].

There are about 600 million people with prediabetic disorders in the world, and their number increases constantly [3]. According to the International Diabetes Federation (IDF), the prevalence of prediabetes is approximately 10% among the adult population in Ukraine [4]. Epidemiological studies have shown that in the group of patients with prediabetes, the risk of type 2 diabetes depends on age, race, degree of obesity and averages 5% per year (from 3.6 to 8.7%) [5]. Some studies have shown that in the first year after detection of IGT, 5–10% of patients develop type 2 diabetes, after 5 years — in 20–33%, and if IGT is combined with IFG, then after 5 years type 2 diabetes develops in 38–65% of patients [1]. Also, as a result of prediabetes, early cardiovascular complications, atherosclerotic lesions of the vascular bed and other serious complications, such as acute coronary pathology and heart failure, may occur [1, 6].

Therefore, early detection of these conditions and their timely correction is a very important problem.

According to many studies, prediabetes is observed in every second obese patient [1]. That is why, when diagnosing prediabetes, attention should be paid not only to indicators of carbohydrate metabolism, but also to body mass index (BMI), waist circumference (WC), hips and their ratio [1]. When this ratio is higher than 1.0 in men and 0.8 in women, we should talk about the presence of abdominal obesity [1]. A 10-fold increase in the risk of type 2 diabetes was found in individuals with high waist circumference values compared to those with the lowest waist circumference values. Based on the analysis of large prospective epidemiological studies in different populations, among different age groups, it was concluded that abdominal obesity is associated with an increased risk of death from any cause over the entire range of BMI values [1, 7].

Today, it is known that type 2 DM is characterized by multiple pathophysiological processes. The increase in the level of glycaemia is due to the prevalence of glucose entering the blood plasma over its release. Fasting hyperglycemia is due to excessive formation of glucose in the liver [8].

It should be noted that the key factors in the development of prediabetes and type 2 diabetes are the insufficiency of  $\beta$ -cells of the pancreas in combination with insulin resistance of target tissues – liver, muscles, adipose tissue, myocardium. Also, the increased supply of fatty acids to the liver leads to their oxidation, which contributes to excessive gluconeogenesis. In addition, changes in circulating levels of adipokines — factors released from adipose tissue (leptin, adiponectin, tumor necrosis factor  $\alpha$ , resistin, visfatin, dipeptidyl peptidase-4, anelin) also form a significant relationship between obesity and the above-mentioned factors in the development of prediabetes and type 2 diabetes [9].

Therefore, there is no doubt about the need for timely detection of early disorders of carbohydrate metabolism; implementation of modern recommendations regarding lifestyle changes, the use of modern medicinal products in order to prevent the onset of type 2 diabetes and cardiovascular diseases.

Today, the main goal of treating patients with prediabetes is the prevention of type 2 diabetes and cardiovascular complications. Both non-drug and drug therapies are effective in preventing type 2 diabetes in people with early disorders of carbohydrate metabolism. In national and foreign recommendations for the prevention of type 2 diabetes in people with prediabetes, special attention is paid to lifestyle modification, that is, measures aimed primarily at losing body weight, the ability to suppress the development of concomitant diseases, and cause no dependence and addiction. According to the guidelines for type 2 diabetes of the European Association for the Study of Diabetes, the European Society of Cardiology 2019 and the American Diabetes Association 2020, the set of measures should consist of maintaining an optimal weight with calorie restriction (if BMI increased); physical activity of about 200–300 minutes per week with moderate physical exertion (e.g. walking, climbing stairs), strength training; restriction of alcohol consumption and smoking [10, 11].

Each of the components of a lifestyle modification program (both diet and physical activity) can affect different risk factors, including metabolic disorders, which ultimately contributes not only to improvements in carbohydrate metabolism, but also to an overall reduction in cardiovascular risk.

If we focus on dietary recommendations, in recent years dietary fiber (DF) has attracted more and more attention as an integral component of a healthy diet. Scientists from the University of Georgia, USA, came to the conclusion that consumption of dietary fiber contributes to the prevention of obesity, metabolic syndrome and adverse changes in the intestine, and helps to the growth of the population of beneficial bacteria in the intestine as well [12]. That is why nutritionists recommend obese people to include dietary fiber in their diet. For normal bowel function, the World Health Organization recommends to consume 400 g (5 servings) of vegetables and fruits containing 25–35 g of dietary fibers every day [13]. According to statistics, Europeans consume only 50–70% of the daily norm of dietary fiber [14], and Americans consume about 16 g daily, and only 5% of people in the USA consume the daily norm of dietary fiber [15].

Dietary fibers are divided into digestible (starch) and non-digestible carbohydrates (cellulose, hemicellulose, pectin, and others). The most important are non-digestible carbohydrates, because they increase intestinal peristalsis, reduce the absorption of nutrients and the feeling of hunger, lower the glycemic index of products and promote the growth of normal intestinal microflora [16].

Due to their properties, dietary fiber binds water, swells, increases the volume and stretches the stomach, creating a feeling of satiety during meals, and a feeling of satiety between meals. In addition, during the microbial fermentation of dietary fiber in the intestine, short-chain fatty acids (SCFA) are released. Acting locally at the level of enteroendocrine L-cells, SCFA can contribute to the release of anorexogenic hormones: glucagon-like peptide 1 (GLP-1) and peptide YY (PYY) with the effect of slowing down the emptying of the stomach and small intestine. The rate of gastric emptying and the time of transit through the small intestine cause postprandial changes in the levels of glucose and insulin in the blood, correlating with feelings of satiety, reducing the feeling of hunger and the amount of food consumed. In addition, dietary fiber is prebiotic that increases the intestinal colonization of *Bacteroidetes* and *Actinobacteria*, which predominate in lean individuals, and reduce the contamination of *Firmicutes* and *Proteobacteria*, which predominate in obese individuals [17].

Psyllium, obtained from the husk of plantain seeds (*Plantago ovata*) and known in Western countries as isfagula, is among the most well-known and studied dietary fibers in medical practice. Numerous studies show that psyllium has a positive effect on the functioning of many organs and systems, including the work of the pancreas, intestines and heart muscle. Psyllium consists of three fractions, each of which contributes to the normalization of intestinal functions:

- fraction A (30%) is a non-fermentable fraction ensuring the normalization of intestinal motility and acting as a bulking agent;
- fraction B (55%) is a gel-forming fraction binding water and bile acids, cholesterol and toxins;
- fraction C (15%) is a rapidly fermenting fraction promoting the growth of lacto- and bifidobacteria [18, 19].

Due to the combination of different fractions, psyllium has a positive complex effect on the intestines and on the whole body in general.

In one study, psyllium has been shown to be effective for weight loss in obese individuals, and lowering cholesterol as well. Plantain seed husk absorbs a large amount of liquid when it enters the gastrointestinal tract. Due to the fact people feel satiety, and this allows to reduce the amount of food consumed, which leads to a decrease in body weight [20].

The results of a meta-analysis of 35 randomized clinical trials have shown that taking psyllium before meals effectively reduces elevated fasting glucose concentrations. The obtained data are clinically significant: the HbA1c level decreases by 1% (10.6 mmol/mol), which can be compared with the effect of many drugs used to treat diabetes [21].

When taking psyllium, a gel fraction binding bile acids is formed in the small intestine. When a sufficiently large amount of bile acids are bound, their reabsorption in the distal part of the ileum decreases and their excretion with feces increases as well. This subsequently leads to a decrease in the level of cholesterol in the blood. The loss of bile acids activates intracellular cholesterol 7-hydroxylase, which contributes to the increased formation of bile acids from cholesterol and the reduction of its reserves inside the cells. As a result, the activity of low-density lipoprotein (LDL) receptors on the surface of cells increases and the extraction of LDL cholesterol from the blood increases, which leads to a decrease in the level of cholesterol in the blood plasma. The soluble substances of psyllium are disintegrated by the intestinal flora into triglycerides, inhibiting HMG-CoA reductase, which reduces new cholesterol synthesis. Also, psyllium helps to reduce the absorption of cholesterol from the intestines.

The effectiveness of hypolipidemic action of psyllium has been proven in more than 50 randomized clinical trials, where psyllium was prescribed both a food supplement, and a medicinal product. On average, the cholesterol level decreased by approximately 10–15% [19]. Total cholesterol levels decreased by 14.8% and LDL levels decreased by 20.2% in one study involving patients with mild to moderate hyperlipidemia who received psyllium three times a day. The LDL/high-density lipoprotein ratio improved by 14.8% compared to baseline values [22].

Another study has proven that with long-term use (more than 6 months) of psyllium at a dose of 15 g per day in overweight and obese patients, a decrease in the level of total cholesterol (by 4.8%,  $p = 0.006$ ) and the concentration of triglycerides (by 12.7%,  $p = 0.023$ ) was observed [23].

Therefore, dietary fibers reduce the risk of development and progression of obesity, metabolic syndrome, type 2 diabetes and cardiovascular diseases.

On the pharmaceutical market of Ukraine there is a herbal complex for the normalization of intestinal functions — Fibolex®, which includes dietary fibers, such as plantain seed husk (psyllium), natural wheat fibers and green tea extract. The dietary fibers contained in Fibolex® contribute to the normalization of intestinal functions, improve the motility of the large intestine, facilitate the defecation process in cases of

constipation/conditions accompanied by a delay in defecation, and improve the condition of the intestinal microflora as well (create favorable conditions for the growth of lacto- and bifidobacteria).

Due to its hydrophilic properties, psyllium, contained in Fibolex® complex, absorbs a large amount of liquid when it enters the gastrointestinal tract, thanks to which people feel satiety more quickly. This feature allows to reduce the amount of food consumed by overweight people. The enteroabsorbing effect of dietary fibers contained in Fibolex® complex, contributes to the binding of an excess amount of bile acids and the elimination of endotoxins, allergens and products of intestinal metabolism, thereby reducing the intoxication symptoms. Also the dietary fibers accelerate the processes of restoration of the intestinal mucosa, and improve indicators of carbohydrate and lipid metabolism.

Due to the combined herbal composition, Fibolex® complex can be used in people with obesity, prediabetes, metabolic syndrome, type 2 diabetes and other metabolic disorders in order to correct food habits to improve the indicators of carbohydrate and lipid metabolism.

Fibolex® is a food supplement. It is not a medical preparation.