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THE EFFECT OF DIET MODIFICATION ON THE DYNAMICS OF INSULIN RESISTANCE IN PATIENTS WITH TYPE 2 DIABETES MELLITUS

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Abstract
Diet modification is one of the key non-drug methods for correcting insulin resistance in patients with type 2 diabetes. This article analyzes current clinical data, including randomized controlled trials, meta-analyses, and large cohort observations published between 2010 and 2025. Particular attention is paid to assessing the dynamics of insulin resistance indicators (HOMA-IR, fasting insulin level, euglycemic index) against the background of various dietary patterns, including the Mediterranean diet, low-carbohydrate schemes, low-glycemic index and low-load diets, intermittent fasting, and increased dietary fiber intake.

Keywords: Type 2 diabetes mellitus, insulin resistance, HOMA-IR, dietary interventions, Mediterranean diet, low-carbohydrate diet, low glycemic index, intermittent fasting.

Introduction

The scientific novelty of the article lies in the fact that for the first time in a single review the clinical effects of various dietary strategies are compared with the key pathophysiological mechanisms of insulin resistance , which makes it possible to strengthen the scientific validity of practical recommendations for dietary therapy for type 2 diabetes mellitus.

Type 2 diabetes mellitus is a global pandemic, characterized by insulin resistance combined with relative insulin deficiency. Insulin resistance is a key pathophysiological factor preceding hyperglycemia and is closely associated with abdominal obesity, chronic inflammation, and atherogenic dyslipidemia, which ultimately worsens cardiovascular prognosis. The role of insulin resistance is confirmed by both clinical metrics (e.g., HOMA-IR, euglycemic index and clamp), as well as extensive experimental data [1].

Dietary modification is recognized as one of the fundamental non-pharmacological methods for the treatment and prevention of type 2 diabetes. Diet influences not only energy balance and body weight but also many other factors: postprandial glycemic fluctuations, insulinemia profile, gut microbiota composition, systemic inflammation, and metabolic pathways in target tissues (muscle, liver, adipose tissue) [2]. Thus, diet can indirectly influence insulin resistance through weight loss and changes in fat distribution, as well as through nutrient composition (type of fatty acids, fiber content, and bioactive components).

Over the past decade, large randomized controlled trials (RCTs) and meta-analyses have assessed the effectiveness of various dietary approaches:

1. Mediterranean diet. Prospective studies (e.g., PREDIMED) and RCTs demonstrate that a Mediterranean diet reduces the risk of developing type 2 diabetes and improves metabolic markers. This beneficial effect is due to the high content of monounsaturated fats, polyphenols, and dietary fiber, which reduce oxidative stress and inflammation, providing a strong evidence base for cardiometabolic prevention [3].
2. Carbohydrate restriction (low-carbohydrate/ keto diets). These approaches have shown greater short- and medium-term improvements in glycemia and insulin resistance (up to 3–6 months) compared to traditional low-fat diets [4]. However, long-term safety (lipid profile, kidney function, sustainability of the effect) and tolerability remain a matter of debate and require a strictly individualized approach.
3. Low glycemic index/load (LoGI /GL). Meta-analyses confirm that low GI/GL diets reduce the postprandial insulin load and may lower HOMA-IR, which is especially important for individuals with severe insulin hypersecretion [5].
4. Intermittent fasting (IF). Including time-restricted eating patterns In a 5:2 ratio (federal feeding ratio) and IF, there is potential to reduce fasting insulin levels and improve HOMA-IR and HbA1c. The effect is partly related to weight loss, but there are also independent metabolic effects (autophagy, mitochondrial function). The use of IF in patients on antidiabetic drugs (especially insulin and secretagogues) requires mandatory medical supervision [6].
5. Dietary fiber and microbiota. Increasing fiber intake correlates with a reduction in HOMA-IR and improved glycemic control. Preliminary data indicate that prebiotics / probiotics may modulate insulin sensitivity through alteration of microbiota, short-chain fatty acid production, and anti-inflammatory mechanisms, although further large studies are needed to make definitive clinical recommendations [7].

Despite the significant amount of data, important questions remain:

- the difficulty of separating the effect of diet from the effect of weight loss;
- heterogeneity of methods for assessing insulin resistance (HOMA-IR, clamp, TyG), which makes it difficult to compare results;
- insufficient data on the long-term tolerability and safety of aggressive diets (VLCD/keto, long-term IF) in comorbid patients.

These questions necessitate a systematic review that will focus specifically on the dynamics of insulin resistance markers in patients with type 2 diabetes.

The aim of our work is to systematically summarize and synthesize available clinical data on the impact of various dietary modification strategies on the dynamics of insulin resistance in adult patients with type 2 diabetes mellitus, identify key mechanisms of action, and formulate practical recommendations for clinicians.

The search and selection of publications was carried out in the period from January to March 2025 using the PubMed , Scopus and Web databases . of Science ". In strategy search were included key words And their combinations: “type 2 diabetes mellitus”, “insulin resistance”, “dietary intervention”, “Mediterranean diet”, “low carbohydrate diet”, “glycemic index”, “intermittent fasting”, “dietary fiber”. Selection literature was carried out V in accordance With

recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [8].

The review included original randomized controlled trials, cohort studies, and meta-analyses published in English and Russian between 2010 and 2025. Publications with small sample sizes (<30 participants), animal studies, and non-peer-reviewed sources were excluded. The quality of the included studies was assessed based on design criteria, bias control methods, and completeness of data reporting.

A review of the literature confirms that dietary interventions are among the most effective non-drug approaches for reducing insulin resistance in patients with type 2 diabetes. The most studied and effective approaches include the Mediterranean diet, low-carbohydrate regimens, low-glycemic index diets, increased dietary fiber intake, and intermittent fasting.

Mediterranean Diet. A Mediterranean diet, characterized by high levels of monounsaturated fats, vegetables, legumes, and whole grains, has been consistently associated with significant improvements in insulin sensitivity and reductions in HOMA-IR. For example, the large randomized controlled trial PREDIMED- Reus demonstrated a 30% reduction in the risk of developing type 2 diabetes and an improvement in the overall metabolic profile, even without strict calorie restriction [9].

Low-carbohydrate diets. Schemes that restrict carbohydrates (less than 40% of total calories) have proven effective in significantly reducing HOMA-IR and fasting insulin levels. According to a meta-analysis of 23 RCTs, low-carbohydrate diets demonstrated superiority over standard dietary recommendations in improving markers of insulin resistance [10].

Low-glycemic index diets. A diet based on low -glycemic index foods significantly improves insulin sensitivity, which is particularly noticeable in patients with concomitant hyperinsulinemia. A meta-analysis conducted by scientists revealed a statistically significant reduction in the HOMA-IR index with the use of low-glycemic diets [11].

Increasing dietary fiber intake. Increasing daily fiber intake to 30–40 g/ day improves glycemic control and reduces insulin resistance . This effect is explained primarily by modulation of the intestinal microbiota and a slowing of postprandial glycemia (the rate of glucose absorption). Systematic reviews associate higher dietary fiber intake with positive changes in insulin sensitivity [12].

Intermittent fasting. Despite limited follow-up in clinical trials, intermittent fasting has shown the potential to significantly reduce fasting insulin levels and HOMA-IR. Notably, this effect is observed even without significant weight loss, suggesting the activation of additional, weight-independent metabolic mechanisms. Studies confirm the beneficial effects of IF on markers of insulin resistance, requiring further study of its long-term safety [13].

Table 1 - The effect of different dietary patterns on insulin resistance in patients with type 2 diabetes mellitus

Power model	**Main characteristics**	**Effect on HOMA-IR/insulin sensitivity**	**Duration of observation**
Mediterranean diet	High in MUFA, vegetables, whole grains , nuts, fish	↓ HOMA-IR, ↑ insulin sensitivity	1–4 years
Low-carb diet	Carbohydrates <40% of calories	↓ HOMA-IR, ↓ fasting insulin	3 months – 2 years
Low glycemic index	Limit high -GI foods	↓ HOMA-IR, improved glycemic control	8–52 weeks
Increased fiber intake	30–40 g/ day , mainly soluble	↓ HOMA-IR, improvement of microbiota	12–52 weeks
Intermittent fasting	Restricting meal times (e.g. 16:8)	↓ fasting insulin, ↓ HOMA-IR	4–24 weeks

the Mediterranean and low-carbohydrate diets have the strongest evidence base for reducing insulin resistance. Low-glycemic index, high-fiber, and intermittent fasting approaches are promising, but longer-term RCTs are needed to confirm their sustained effects. Individualizing diets based on the patient's metabolic phenotype is an important factor in the effectiveness of interventions.

Diet therapy improves insulin sensitivity in type 2 diabetes by affecting a complex of metabolic and cellular mechanisms:

1. Reducing saturated fat intake and total caloric intake leads to a decrease in free fatty acid levels and, consequently, a reduction in lipotoxicity. It also restores the key insulin signaling pathway, which is important for the efficient uptake and utilization of glucose by tissues [14].
2. Dietary changes help reduce systemic inflammation, endoplasmic reticulum stress is reduced . The activity of pro-inflammatory proteins is suppressed. kinases that normally disrupt the phosphorylation of insulin receptor substrates. As a result, phosphorylation is normalized, which directly increases the sensitivity of peripheral tissues to insulin [15].
3. Diets rich in dietary fiber have a positive effect on the gut-metabolism axis. Intestinal The microbiota actively produces short-chain fatty acids, which reduce endotoxinemia (the concentration of bacterial toxins in the blood). The secretion of incretins is stimulated, which enhance insulin secretion and improve the metabolic response [16].
4. Dietary approaches, including intermittent fasting, activate central metabolic regulators. AMPK (AMP-activated kinase) is activated. The activity of the transcription factor FoxO1 is reduced. This leads to a decrease in gluconeogenesis in the liver and an increase in fat oxidation. IF additionally improves mitochondrial function and triggers autophagy (the cellular "self-cleaning" process), promoting the renewal of metabolically active tissues [17].

The combination of these mechanisms-restoring signaling, reducing inflammation, improving intestinal metabolism, and optimizing cellular energetics-reduces the metabolic load on pancreatic beta cells and increases systemic insulin sensitivity, confirming the key role of diet therapy in the treatment of type 2 diabetes.

Current evidence confirms that dietary modification is an effective tool for correcting insulin resistance in patients with type 2 diabetes and prediabetes. The most evidence-based strategies are:

1. The Mediterranean diet is high in vegetables, whole grains , nuts, fish and olive oil as the main source of fat.
2. Moderate restriction of carbohydrates (up to 40% of calories), with priority given to foods with a low glycemic index and the elimination of refined sugars.
3. Increasing dietary fiber intake (≥30 g/ day) to modulate microbiota and improve metabolic control.
4. Calorie control for the purpose of maintaining or losing body weight, which significantly increases tissue sensitivity to insulin.
5. Consider intermittent fasting (e.g. 16:8 regimen) in motivated patients without contraindications.

It is recommended to individualize the approach based on the patient's clinical profile, comorbidities, and preferences. Diet therapy is most effective when combined with physical activity and lifestyle modification.

Thus, dietary modification is a highly effective and key non-pharmacological tool for improving insulin sensitivity in patients with type 2 diabetes. For successful clinical practice, an individualized approach, taking into account patient preferences and comorbidities, is essential. When implementing aggressive diets, careful laboratory monitoring is essential. Further long-term randomized controlled trials with consistent endpoints are needed to definitively determine the optimal long-term nutritional strategy capable of maximally reducing insulin resistance and the risk of complications in type 2 diabetes.

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