UDC 616. 008+612.3
DOI https://doi.org/10.32689/2663-0672-2025-1-5

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INFLUENCE OF NUTRITIONAL STATUS ON THE RISK OF DEVELOPING METABOLIC SYNDROME IN OBESE PATIENTS

Today, the problem of obesity is relevant on a global scale due to the associated metabolic and cardiovascular complications that lead to the development of metabolic syndrome. The metabolic syndrome (MS) is a combination of metabolic risk factors characterised by abdominal obesity, dyslipidaemia, low high-density lipoprotein cholesterol, hypertension and insulin resistance, which leads to the development of metabolic disorders such as type 2 diabetes mellitus, chronic kidney disease, and non-alcoholic fatty liver disease, which are the main causes of vascular damage.

Lifestyle changes, especially in eating habits, are the main therapeutic strategy for treating and preventing metabolic syndrome. This study provides practical ideas for improving treatment in collaboration between clinicians, dietitians, and obese MS patients.

Objective. *To analyse the relationship between nutritional status and the development of MS in obese people.*

Materials and methods. *The study searched and analysed relevant scientific information sources on risk factors for metabolic syndrome and possibilities for its prevention in obese people. The bibliosemantic method, methods of comparative analysis, systematisation and generalisation of information, and structural and logical analysis were used in the study.*

Results and discussion. *The main source of MetS is insulin resistance, which plays a central role in the onset, progression and transition of MetS to other metabolic disorders. Individuals who are prone to increased carbohydrate intake, which contributes to high blood pressure, triglycerides and low-density lipoprotein cholesterol, are at high risk of developing metabolic syndrome. Consumption of foods with a low glycaemic index and high fibre content helps to reduce insulinemia and insulin resistance. A low-fat diet benefits the management of systolic and diastolic blood pressure and improves lipid profile, but only in the short term. Consumption of large amounts of saturated fat and trans fatty acids is associated with a negative impact on insulin action.*

In contrast, consumption of monounsaturated and polyunsaturated fats has the opposite effect. Essential monounsaturated fatty acids and small amounts of polyunsaturated fatty acids support normal cholesterol levels and cardiovascular health. A high-protein diet is effective in treating obesity, as well as MetS and glycaemic control.

Conclusions. *Modern diets and nutrition models have different effects on each risk factor for MS. However, all of them should be compatible with calorie restriction, which is most effective in metabolic disorders. Proper dietary recommendations with controlled energy intake can influence and prevent the development of MS in obese patients.*

Key words: *metabolic syndrome, obesity, nutritional status, insulin resistance, type 2 diabetes mellitus, cardiovascular diseases.*

Неоніла Корильчук. ВПЛИВ НУТРИТИВНОГО СТАТУСУ НА РИЗИК РОЗВИТКУ МЕТАБОЛІЧНОГО СИНДРОМУ У ПАЦІЄНТІВ З ОЖИРІННЯМ

На сьогодні проблема ожиріння є актуальною у світовому масштабі через пов'язані з нею метаболічні та серцево-судинні ускладнення, що спричиняє розвиток метаболічного синдрому. Метаболічний синдром (МС) – це сукупність метаболічних факторів ризику, що характеризується абдомінальним ожирінням, дисліпідемією, низьким рівнем холестерину ліпопротеїдів високої щільності, артеріальною гіпертензією та інсулінорезистентністю, що призводить до розвитку метаболічних розладів, як-от цукровий діабет другого типу, хронічні захворювання нирок, неалкогольна жирова хвороба печінки, які є основними причинами пошкодження судин.

Зміни способу життя, особливо харчових звичок, є основною терапевтичною стратегією для лікування та профілактики метаболічного синдрому. Це дослідження містить практичні ідеї для покращення лікування у співпраці між клініцистами, дієтологами, МС-пацієнтами із ожирінням.

Мета. *Аналіз взаємозв’язку між нутритивним статусом та розвитком МС у людей з ожирінням.*

Матеріали та методи. *У дослідженні проведено пошук та аналіз наукових релевантних інформаційних джерел щодо факторів ризику метаболічного синдрому, можливостей його попередження в осіб з ожирінням. У роботі застосовано бібліосемантичний метод, методи порівняльного аналізу, систематизації й узагальнення інформації та структурно-логічного аналізу.*

Результати й обговорення. *Основним джерелом розвитку МС є інсулінорезистентність, яка відіграє центральну роль у початку, прогресуванні та переході МС до інших метаболічних розладів. Високий ризик розвитку метаболічного синдрому наявний у осіб, які схильні до збільшеного споживання вуглеводів, що сприяє підвищенню артеріального тиску, тригліцеридів та холестерину ліпопротеїнів низької щільності. Споживання продуктів з низьким глікемічним індексом та високим вмістом клітковини сприяє зниженню інсулінемії та резистентності до інсуліну. Дієта з низьким вмістом жиру сприятливо впливає на управління систолічним і діастолічним артеріальним тиском, а також покращує ліпідний профіль, проте лише у короткостроковій перспективі. Споживання великої кількості насичених жирів і трансжирних кислот пов’язане з негативним впливом на дію інсуліну, тоді як споживання мононенасичених та поліненасичених жирів чинить протилежний ефект. Незамінні мононенасичені жирні кислоти та невеликі кількості поліненасичених жирних кислот підтримують нормальний рівень холестерину та здоров’я серцево-судинної системи. Дієта з високим вмістом білка є ефективною при лікуванні ожиріння, МС і контролю глікемії.*

Висновки. *Сучасні дієти та моделі харчування мають різний вплив на кожен фактор ризику МС, але всі вони повинні бути сумісні з обмеженням калорійності, що є найефективнішим при метаболічних порушеннях. Правильні рекомендації щодо харчування з контрольованим енергоспоживанням можуть вплинути та запобігти розвитку МС у пацієнтів із ожирінням.*

Ключові слова: *метаболічний синдром, ожиріння, нутритивний статус, інсулінорезистентність, цукровий діабет другого типу, серцево-судинні захворювання.*

Problem statement. In the Western world, a significant number of people are overweight or obese, and this trend is unfortunately becoming more widespread. It is known that 21% of medical expenses are spent on the treatment of obesity-related diseases. According to the WHO, in 2016, the number of overweight adults exceeded 1.9 billion, of whom more than 650 million (13%) were obese [14]. Today, the food industry is focused on manufacturing food products with reduced amounts of nutrients and trace elements while increasing the calorie content of the product, which contributes to the growing number of overweight and obese patients [1]. The prevalence of obesity is influenced by many genetic and environmental factors, including physical activity, diet, gender, race, and socioeconomic status. In particular, the prevalence of obesity in men is 27.2 per cent higher than in women (10.6 per cent). In addition, marital status and current economic status are associated with obesity in women, but not in men [3].

Obesity is often associated with the following metabolic abnormalities: insulin resistance, high blood pressure, dyslipidaemia and impaired glucose metabolism, which is defined as a metabolic syndrome, a group of conditions that together increase the risk of cardiovascular disease (CVD), type 2 diabetes mellitus (T2DM), stroke and other serious health problems [8]. The presence of metabolic syndrome is indicated by the presence of three or more of the following symptoms [13; 27]: abdominal obesity, which is a greater risk factor for heart disease than excess fat in other parts of the body; high blood pressure (systolic > 130 and/or diastolic > 85 mm Hg); high fasting glucose: >100 mg/dl (5.6 mmol/l), which increases the risk of blood clots; high blood triglyceride levels (>150 mg/dl (1.7 mmol/l)); high levels of low-density lipoprotein cholesterol (LDL), which causes plaque accumulation in blood vessels, and low levels of high-density lipoprotein cholesterol (HDL) (<40 mg/dL (1 mmol/L) (men) or <50 mg/dL (1.3 mmol/L) (women)) (*Fig.1*).

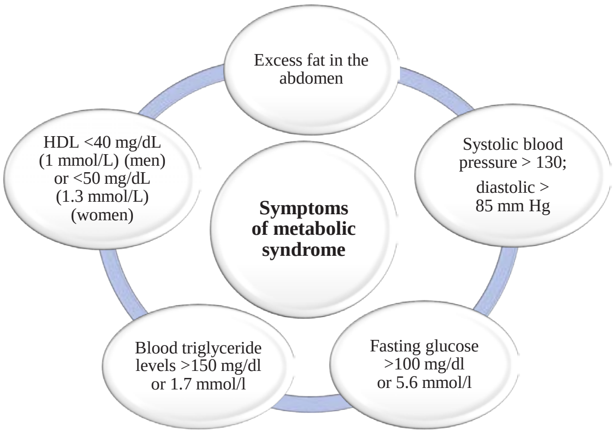

Fig. 1. Symptoms of metabolic syndrome

The distribution of adipose tissue is of great importance for obesity-related comorbidities. It is abdominal obesity that contributes to a particular type of insulin resistance, as its presence indicates the onset of ectopic fat infiltration, and not only in the abdomen. The body resists the role of insulin in promoting the storage of excess energy in the form of triglycerides in adipose tissue, and therefore excess fat accumulates in places other than adipose tissue, such as the liver, muscles, abdomen and perivascular region, causing organ dysfunction and contributing to insulin resistance in the target organ. In turn, insulin resistance causes metabolic diseases, such as non-alcoholic fatty liver disease (NAFLD) and T2D [9; 27].

It is known that obesity-related dyslipidaemia, hypertension, insulin resistance, vascular endothelial dysfunction, and sleep disorders can contribute to the development of cardiovascular disease (CVD). Comorbidities associated with obesity, such as chronic kidney disease and NAFLD, also contribute to the development of CVD [29; 35].

It is well known that there is a close relationship between nutritional status and the incidence of metabolic syndrome. The results of a study by Putri et.al. [22] confirm that an obese person is 5.091 times more likely to develop metabolic syndrome than a person with a normal nutritional status or a thin person. This is due to the fact that obese people have a higher risk of developing other complications.

Currently, much attention is paid to the assessment of nutritional status in obese patients. It is recommended to use combinations of biochemical, somatometric and immunological indicators. In the study of somatometric parameters, the main classification is based on the determination of the Ketle index or body mass index (BMI), which is calculated as the ratio of body weight in kilograms to the square of body length in metres. A BMI value of 25-30 kg/m^2 indicates overweight, 30-35 kg/m^2 indicates moderate obesity, and more than 35 kg/m^2 indicates severe obesity [29]. Studies have shown that a shift in this indicator from the normative values may potentially indicate an exacerbation of chronic processes, complications, and severe disease [36]. In the assessment of obese patients, it is also recommended to use waist circumference, which is highly correlated with intra-abdominal fat, the thickness of the skin-fat fold above the triceps, which characterises the reserves of subcutaneous (visceral) fat in the body, and the circumference of the shoulder muscles, which indicates the somatic protein pool to better define the phenotype and assess individual metabolic risk [2; 36].

The International Diabetes Federation (IDF) also uses blood pressure as an important criterion for the diagnosis of MS. Equally important diagnostic criteria of high value are blood glucose levels and lipid profile assessment. The level of total protein can give false results in case of increased globulin fraction and dehydration. The levels of albumin, transferrin, prealbumin, retinol-binding protein, creatinine, and 3-methylhistidine are informative [8].

The main goal of MS treatment is weight loss and reduction of insulin resistance. However, the issue of monitoring nutritional status in correlation with the presence and progression of metabolic syndrome is an important step that could prevent the development of the disease in obese people in the future. Collecting and analysing data on the peculiarities of MS development depending on the type of diet will help to formulate a single correct approach to prevention, elimination of negative consequences and elimination of risk factors.

Analysis of recent research and publications. Healthy eating behaviours, such as a conventional plant-based diet with soy protein or organic foods that follow dietary guidelines, may be negatively associated with MS components. At the same time, a positive association has been noted between the amount of food consumed, the speed of food intake, and the prevalence of pre-metabolic and metabolic syndromes. Recent studies suggest that a poor quality Western-style diet was an independent predictor of increased MS in metabolically unhealthy patients [23].

A study by Cruz et al. [7] showed that obese children aged 10-16 years had a greater tendency to have abnormal values of waist circumference (15% probability), systolic blood pressure (3.66%), elevated triglycerides (7.29%) and glucose (3.66%). The differences in risk factors between obese and normal-weight children were significant, revealing a strong association between obesity and MS. In addition, the study found that the overall prevalence of MS was 7.9 per cent in the sample of school-age children. However, only 0.7 per cent of normal-weight children and 9.7 per cent of overweight children were diagnosed with MS, while the figure for obese children was 72.4 per cent. This relationship ($p = 0.001$) demonstrates that obese children were 24.37 times more likely to meet the criteria for MS diagnosis.

According to various epidemiological studies and clinical trials, people with MS can improve their condition by changing their lifestyle, including dietary changes and increased physical activity.

The leading cause of obesity and overweight can often be overeating. However, some studies show a high prevalence of nutritional deficiencies in obese people compared to people of the same age and gender with normal weight. This can be explained by consuming high-calorie foods, namely fast foods high in carbohydrates, saturated fats and foods that are poor in nutrients (folic acid, retinol, beta-carotene, iron, calcium, vitamins D, E and C). In addition, obesity can lead to impaired absorption of specific nutrients. Another reason may be frequent attempts to lose weight using different types of diets with irrational consideration of the body's nutritional needs [1]. Another study found that children tended to lose weight in secondary school when they were familiar with nutritional knowledge and tools for weight management [7].

According to the study by Quarta et al. [25], which analysed the role of nutrition during growth and its impact on the risk of developing metabolic syndrome and cardiovascular complications in later life, parental nutrition plays an important role in determining offspring's phenotypic characteristics before conception. During intrauterine development, the main risk factors are unbalanced maternal nutrition, excessive gestational weight gain and glycaemic disorders. Breastfeeding, on the other hand, has many beneficial effects, but at the same time, the quality of breast milk can be altered if the mother remains overweight or obese. Knowledge of these mechanisms may allow early modification of risk factors through targeted prevention strategies.

The study by I. Dash et al. [8] involved 260 respondents (180 in the experimental group and 180 in the control group). It investigated the incidence of metabolic syndrome in patients consuming fast food compared to healthy people. In the experimental group, which had an unhealthy and unbalanced diet, about 98% of people suffered from MS, 90% had high cholesterol, 35% had high sugar, and 25% had high triglyceride levels, compared to the control group. In the experimental group, 89.4 per cent of people were found to have a high BMI, indicating that they were obese or overweight.

In recent years, many studies have been devoted to identifying and determining the consequences of the development of MS. However, the study of dietary patterns and nutritional status offers a comprehensive assessment of the impact of food combinations on the health of obese individuals at risk. In particular, a study examining the relationship between total sugar intake and MS in middle-aged people shows that attention should be focused on total sugar intake and its contribution to total energy intake [32].

By analysing the impact of nutritional status, researchers can gain a deeper understanding of the complex interactions between different foods and their effects on metabolism, providing a scientific basis for effective health strategies. Another benefit of using dietary models in research is identifying potential synergistic effects within a diet and their long-term impact on overall health. In addition, research shows that combining dietary therapy with physical activity can effectively improve metabolic status in patients with MS [24].

The need to develop and implement new markers of diagnosis and prognosis to monitor the development and progression of MS risk factors, which is especially important in obese patients, is becoming more urgent. There is an urgent need to assess the relationship between obesity, the development of MS and the impact of nutrition on MS risk criteria, which is important for optimising the management and treatment of patients.

Objective. This study aims to analyse the relationship between nutritional status and the prevalence of MS in obese people.

Materials and methods. A search and analysis of relevant scientific information sources on risk factors for metabolic syndrome and possibilities for its prevention in obese people was carried out. The bibliosemantic method, methods of comparative analysis, systematisation and generalisation of information, and structural and logical analysis were used in the study. The authors present the main research material with full justification of the scientific results obtained.

Results and Discussion. The pathogenetic mechanisms of MS are complex and not yet fully understood, but systemic inflammation, also known as low-grade chronic inflammation, has been recognised as an important common factor. Ectopic lipid accumulation in the muscles and liver has been shown to predispose to insulin resistance syndrome, which plays a central role in the onset, progression and transition of MetS to CVD and T2D. The key role is played by adipose tissue, which is now considered an endocrine organ and undergoes hypertrophy and hyperplasia in response to excess calorie intake. Thus, the excess visceral adipose tissue typical of MetS can lead to metabolic disorders and structural changes, especially in the vascular and lymphatic microenvironment, responsible for potentially lethal hypoxic conditions for adipocytes located further away from the vessels. Hypoxia and lipotoxicity of adipocytes are accompanied by the release of fatty acids and other potential substrates that activate pro-inflammatory pathways in the parenchymal cells of the tissue. This inflammatory process occurs at multiple sites in visceral adipose tissue with excessive systemic inflammatory cytokine distribution that affects visceral and insulin-sensitive organs.

Obese people are often in a state of over-nutrition and insulin resistance, which leads to increased fat synthesis and elevated levels of inflammatory factors such as tumour necrosis factor-α (TNF-α), interleukin-6 (IL-6), C-reactive protein (CRP) and plasminogen activator inhibitor-1 (PAI-1). These inflammatory factors directly disrupt endothelial function, promote atherosclerosis and induce oxidative stress, exacerbating inflammation and causing cell and tissue damage. This process contributes to the formation and rupture of atherosclerotic plaques, induces thrombosis and increases the risk of CVD. In addition, adipose tissue can secrete many other adipocytokines (leptin, resistin, visfatin). Adipocytokines, namely omentin and adiponectin, which are secreted from visceral adipose tissue, have anti-inflammatory functions. They can regulate the production of nitric oxide (NO) in endothelial cells and inhibit vascular calcification to prevent atherogenesis and inflammation.

In contrast, the expression of resistin and TNF-α contributes to insulin resistance in obesity and type 2 diabetes. IL-6 is an important cytokine in myocardial lipid accumulation. Blocking the expression of IL-6 or its receptor for the perturbed IL-6 signalling pathway reduces the risk of coronary heart disease and atrial fibrillation [39; 42].

Insulin resistance in adipose tissue impairs the inhibition of insulin-mediated lipolysis, leading to an increase in circulating free fatty acids, which further inhibits the anti-lipolytic effect of insulin. In skeletal muscle, these free fatty acids can inhibit insulin-dependent glucose uptake. On the other hand, insulin resistance in skeletal muscle and liver disrupts glucose transport and glycogen synthesis, leading to increased insulin secretion by β-cells as a compensatory mechanism to maintain euglycaemia and eventually leads to T2D. In addition, systemic oxidative stress caused by obesity and insulin resistance leads to increased activation of downstream signalling cascades that cause atherogenesis and tissue fibrosis [2: 6; 15; 28].

Changing the diet to support a 7-10% weight loss is a priority goal for obese and overweight people. Regardless of the balance of nutrients in the diet, total energy intake should be appropriate to achieve weight management goals.

Current research shows that MS is closely related to diet. In particular, carbohydrate intake is associated with MS, and reducing carbohydrate intake can be an effective therapy. Excessive sugar consumption is directly correlated with hyperglycaemia and its complications [15]. It is known that the metabolic effects of foods containing carbohydrates can be partially predicted by their glycaemic index (GI). When the GI is low (55 or less), it means that the food causes a slower increase in blood glucose levels, and thus insulin levels. Related to this index is the concept of glycaemic load (GL), which combines both the quantity and quality of carbohydrates. If the carbohydrate content of 100 g of potatoes is 14 g and the GI is 85, the GI is 85 × 14/100 = 12, which is more than twice the GI of 100 g of apple, which is 5. The concept of GI allows you to determine the response of blood glucose levels to different types and amounts of foods. The GI depends not only on the composition of carbohydrates but also on other factors: the physical form of the food, the content of amylose or amylopectin, the complete composition of the food, the presence of fibre, the cooking process, etc [41].

As noted above, the main concern concerning MS is the development of diabetes and the associated risk of cardiovascular failure. It is believed that increased consumption of high GI carbohydrates directly causes insulin resistance and contributes to the development of type 2 diabetes in people with MS. As a rule, low GI foods also contain more fibre. A fibre-rich diet has been shown to reduce insulinemia by 10% and insulin resistance (as measured by the HOMA index) by 13%. Fibre intake increases satiety and reduces the risk of developing type 2 diabetes, and in patients with this diagnosis, fibre supplements improve conventional markers of glycaemic control that should be considered in treatment [13; 16].

Prolonged daily intake of fructose, which does not stimulate insulin or leptin secretion upon absorption, leads to weight gain and decreased insulin sensitivity, contributing to the development of MS and type 2 diabetes in both children and adults, but moderate fructose intake ≤50 g/day or ~10% of energy has no adverse effect on lipid and glucose control, and ≤100 g/day has no effect on body weight [13].

Fasting plasma glucose and fasting insulin levels can be used to assess weight loss success following a low-carbohydrate or low-fat diet. An increase in fasting plasma glucose is positively correlated with successful weight loss and maintenance in overweight patients with diets low in glycaemic load or high in fibre and whole grains [40]. A low-carbohydrate diet is based on mechanisms to avoid the rapid absorption associated with certain types of carbohydrates, namely glucose and refined grains, which leads to increased insulin resistance and insulin requirements. In a meta-analysis of 18 studies involving 69,554 patients with MS, Lui, et.al. [19] concluded that the risk of development was increased in individuals with a higher carbohydrate intake. In addition, those with a high intake of these substances experienced effects such as elevated blood pressure, triglycerides and LDL cholesterol and lower HDL cholesterol.

Among the low-carbohydrate diets, it is postulated that ketogenic diets with very low levels of these compounds (up to less than 10% of daily energy intake) and a relative increase in fat intake (3:1 to 4:1 ratio of fat to carbohydrate and protein intake) have a therapeutic role in overweight and obesity, cardiovascular disease, and MS. This restrictive diet has been shown to have a protective effect against obesity and cardiovascular disease by reducing body weight and improving lipid profiles. This type of diet contributed to greater weight loss, lower triglyceride levels and diastolic blood pressure compared to a low-fat diet. There are several mechanisms of action that explain this effect:

– the absence of dietary carbohydrate intake leads to a decrease in insulin secretion and inhibition of lipogenesis, fat storage and increased lipolysis;

– the satiety effect of protein consumption affects appetite control hormones (leptin and ghrelin);

– modulation of insulin secretion and ketone body production, which can lead to metabolic improvements, especially in insulin signalling.

In addition, the carbohydrate restriction and glycogen depletion that characterise this type of diet result in the use of ketone bodies as the primary source of energy. However, energy restriction is necessary to maintain ketone body production.

Thus, studies show that the reduction in body weight and the development of cardiovascular disease observed in ketogenic diets are associated with energy restriction despite the distribution of macronutrients in the diet [5]. Consumption of high-fat foods, especially excessive intake of saturated fatty acids, is closely associated with several key symptoms of MS [20]. The amount of fat can only affect insulin sensitivity and the risk of developing type 2 diabetes if it is consumed at more than 35-40% of total energy intake. A diet containing 20-40% fat does not change insulin sensitivity, regardless of its effect on weight. Consumption of large amounts of saturated fat and trans fatty acids is associated with changes in insulin action, while consumption of monounsaturated fat has the opposite effect.

Thus, insulin sensitivity is associated with the monounsaturated fatty acid/saturated fat ratio. Along with this effect on insulin, diets enriched in monounsaturated fatty acids improve lipid profile, reducing LDL cholesterol and triglycerides and increasing HDL cholesterol. Polyunsaturated fats are associated with a 40% lower relative risk of developing type 2 diabetes. In studies involving patients with type 2 diabetes, replacing saturated fatty acids with polyunsaturated fatty acids and carbohydrates with monounsaturated fatty acids reduced insulin resistance. In addition, ω-3-polyunsaturated fatty acids can lower triglyceride levels, improve hypertension, reduce inflammation, and reduce the risk of cardiovascular disease in patients with diabetes [13].

European protocols recommend replacing foods rich in trans or saturated fats (solid margarines, tropical oils, fatty or processed meat, sweets, cream, butter and regular cheese) with monounsaturated fats (extra virgin olive oil) and polyunsaturated fats (non-tropical vegetable oils). Thus, it is assumed that trans fats will make up <1.0% of total energy, and saturated fats <10% (<7% in the presence of high plasma cholesterol) [20].

Evaluating low-fat diets, which contain increased carbohydrate intake and moderate protein intake (approximately 15-17% of total energy intake) on the development of MS, has shown conflicting results. Dietary interventions based on low-fat intake (approximately 20 % of total energy intake from fat) slightly reduced the components of MS, but this was not associated with a lower prevalence of MS in older adults at high risk of cardiovascular disease. A low-fat diet had a favourable effect on the management of systolic and diastolic blood pressure. It improved HDL and LDL cholesterol levels in the short term compared with a normal diet, but these effects were reduced in long-term interventions [31].

A low-fat diet that induces weight loss moderately reduces inflammatory biomarkers such as high-sensitivity C-reactive protein (CRP), IL-6, and TNF-α. However, these results are inconclusive, and the effects studied depend on weight loss and dietary composition, including dietary fibre, fruits, and vegetables [21].

Protein intake plays a crucial role in muscle protein synthesis and maintenance of muscle mass, thereby affecting the overall metabolism of the body [20]. A wide range of 10-35% of energy intake in the form of digestible protein is generally recommended for adults. It is assumed that patients with diabetes and normal kidney function should get 15-20% of their energy intake from protein. However, there is no definitive evidence to recommend an ideal amount of protein for glycaemic control or improving cardiovascular risk factors [13].

Protein can play an increasing role. Its consumption is associated with higher insulin secretion, equivalent to that caused by the same amount of glucose. Some amino acids, such as leucine, lysine or alanine, stimulate insulin secretion. However, homocysteine can suppress it. A study by D. Sluik et al. [34] suggests the use of hyperprotein diets in the treatment of MS due to the satiating effect of proteins. These diets also contribute to the preservation of lean mass but may increase urinary calcium excretion and bone remodelling.

High-protein diets (20-30% of daily energy intake from protein) with carbohydrate restriction have been shown to be effective in weight loss in adults with obesity and MetS [26]. Today, a high-protein diet is expected to be used to treat obesity, MS and glycaemic control. The mechanism underlying the potential health benefits of a high-protein diet, is that protein induces a feeling of satiety that translates into reduced energy intake during subsequent meals. In addition, high protein intake prevents muscle loss during energy-restricted dietary interventions for weight loss [5].

Nutritionists advise to prefer plant-based protein sources (soy, legumes, nuts and seeds) to meat and processed meat, as they are rich in fibre, phenolic compounds and polyunsaturated fatty acids, while cholesterol, trans or saturated fatty acids are found in lower proportions. In a meta-analysis, red meat consumption had no effect on blood lipid profile or blood pressure, while after analyses stratified by type of comparative diet, replacing red meat with plant-based protein foods showed a reduction in total cholesterol and LDL cholesterol levels [10]. Thus, there is strong evidence for the beneficial consumption of plant-based protein food sources, which should also be recommended to promote environmental sustainability.

According to a study by Hoyas and Leon-Sanz [13], several dietary patterns may be useful for reducing the risk of MS, such as the Mediterranean diet, vegetarian diet, DASH (Dietary Approaches to Stop Hypertension) diet, low-carbohydrate diet, or even low-fat diet. Different models have different effects on each risk factor, but all of them should be compatible with calorie restriction, which is most effective for metabolic disorders. The DASH diet (Dietary Approaches to Stop Hypertension), rich in fruits, vegetables and low-fat dairy foods and low in saturated and total fat, has been shown to reduce weight and significantly lower blood pressure. A Mediterranean-style diet rich in whole grains, fruits, vegetables, nuts, and olive oil, compared with a rational diet (50-60% of energy from carbohydrates and <30% from fat), was associated with a significant reduction in markers of systemic vascular inflammation in patients with MS after two years of follow-up. The Mediterranean style, vegetarianism and DASH diet contributed to a reduction in the risk of developing T2DM.

Plant-based diets have been consistently associated with favourable cardiometabolic effects, including a lower risk of developing MetS and all its components. In addition, these dietary patterns are associated with a reduced risk of obesity, type 2 diabetes and cardiovascular disease. A lower risk of coronary heart disease mortality has been reported in vegetarians compared to non-vegetarians. In addition, recent systematic reviews and meta-analyses have found a significant association between adherence to the MedDiet and DASH diets and a 38% and 20% reduction in cardiovascular disease risk, respectively, while a vegetarian diet was associated with a 28% reduction in coronary heart disease risk [17]. A mean reduction of 6.9 mmHg in systolic blood pressure and 6.3 mmHg in diastolic blood pressure was also reported in participants on a vegetarian diet compared to a control omnivorous diet [12]. Other studies evaluating plant-based diets, such as MedDiet, have also described positive effects on body weight and waist circumference [18]. Among plant-based foods, the antioxidant effect of several nutrients and bioactive compounds (vitamin C and E, β-carotenes and polyphenols) has been linked to the prevention of cardiovascular disease and metabolic syndrome.

Thus, the replacement of certain animal products involves limiting the consumption of harmful components that are mainly present in red and processed meat (excessive sodium, which poses a potential risk to blood pressure regulation and increases the likelihood of MS, as well as heme iron, nitrates and nitrites, which are associated with the consequences of cardiovascular disease) [12].

A study of the association between dietary patterns and MS [19] indicates that a legume and nut diet, which contains potatoes, beans, nuts, fruits, white meat, liquids and seafood and is characterised by a high intake of carbohydrates and sugars, especially from potatoes and some legumes that naturally contain significant amounts of starch and sugars, is significantly associated with an increased risk of developing MS. In the absence of sufficient dietary fibre to mitigate these effects, there is an increased risk of sudden spikes in blood sugar. Although fruits are rich in natural fructose, excessive consumption can also lead to fluctuations in sugar levels. Nuts and seafood, while providing healthy unsaturated fats that support cardiovascular health, can contribute to weight gain and negatively affect metabolic health if consumed in excess without adequate physical activity. In addition, processed white meat and seafood may contain high levels of sodium [4]. Conversely, an egg-and-vegetable diet, characterised by a high intake of eggs, fresh vegetables, whole grains, oils, and white meat, containing high quality proteins, low fat, high amounts of fibre, vitamins, minerals, and carbohydrates, is associated with a reduced risk of MS.

This finding is consistent with a long-term study conducted in Australia [38], which also demonstrated that a diet rich in fruits, vegetables and whole grains is associated with a lower risk of MS. The high fibre content of whole grains and fresh vegetables helps to slow down digestion and absorption, which in turn stabilises blood sugar levels and promotes a prolonged feeling of fullness, thus preventing excessive consumption of high-calorie foods. Eggs are a valuable source of protein, which is essential for maintaining muscles and overall metabolic health. Additionally, healthy cooking oils such as olive oil contain essential monounsaturated fatty acids and small amounts of polyunsaturated fatty acids, both of which support normal cholesterol levels and cardiovascular health. In addition, the low sugar content of this diet helps to prevent metabolic disorders, including insulin resistance and diabetes.

Conclusions. In summary, people, especially those who are obese, should choose a high-fibre, low-sugar diet and avoid high-fat, high-carbohydrate diets. This approach can help with weight control, improve blood sugar regulation, and ultimately reduce the risk of MS. People with a high carbohydrate intake have a significant risk of developing MS. Consumption of large amounts of saturated fat and trans fatty acids is associated with altered insulin action. In contrast, monounsaturated and polyunsaturated fats have the opposite effect. In addition, diets enriched in monounsaturated fatty acids improve lipid profile, reducing LDL cholesterol and triglycerides and increasing HDL cholesterol. Diets with high protein intake have positive effects in terms of weight loss in obese and MetS patients. However, strong evidence suggests that plant-based protein sources rich in fibre, phenolic compounds and polyunsaturated fatty acids are preferred. Modern diets and eating patterns have different effects on each risk factor for MS, but they should all be coordinated with calorie restriction, which is most effective in metabolic disorders. This study provides practical ideas for fruitful collaboration between clinicians and nutritionists, which will improve the treatment of MS in obese patients.

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