

Understanding Metabolic Syndrome and its Nutritional Management

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Abstract

Metabolic syndrome (MetS) is a collection of risk factors, especially when at least three occur together, including abdominal obesity, dyslipidemia, low high-density lipoprotein cholesterol (HDL-c) levels, hypertension, and insulin resistance. MetS is linked to an increased risk of diabetes and cardiovascular diseases (CVDs) if treatment is not received. The causes of MetS include both genetic and acquired factors that contribute to issues such as insulin resistance, chronic low-grade inflammation, and obesity. One of the primary approaches to treating and managing metabolic syndrome is through lifestyle modifications, particularly changes in dietary habits. Although the most effective dietary strategy has yet to be determined, specific dietary adjustments such as upgrading the quality of the food or modifying distribution of macronutrients in the food, have shown helpful results in managing metabolic syndrome conditions. However, energy-specific dietary practices and scaling down physical inactivity are essential in improving metabolic disturbances thus in the present review detailed risk factors and management of metabolic syndrome will be discussed.

Keywords: Metabolic syndrome, abdominal obesity, insulin resistance, management, nutraceuticals, dietary patterns,

INTRODUCTION

Metabolic syndrome (MetS) is a clinical condition defined by the presence of group of risk factors, specifically when at least three of these risk factors occur together.

These risk factors include – central obesity {accumulation of excess fat in abdominal area}, dyslipidemia {elevated cholesterol of lipids (fat) level in blood}, impaired glucose metabolism {increase in the level of blood sugar levels than the normal levels }, elevated blood pressure and low high-density lipoprotein cholesterol {HDL-c}levels, according to the consensual definition of the International Diabetes Federation, the American MetS is linked to an increased risk of diabetes and cardiovascular diseases (CVDs) if treatment is not received (Figure 1).

According to different epidemiological studies the prevalence of Metabolic Syndrome (MetS) among young people worldwide is approximately 5 to 7% while in industrialized countries the prevalence has escalated to 20-25% in the mature population with its frequency increasing with age. [2] [3-6].

However, the prevalence of metabolic syndrome varies from country to country. For instance, in India, it is 20 to 25%; in the USA, it is 28%; in Turkey, it is 33.4%; and in Saudi Arabia, it is 39.3%. [7] (Table 1).

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ETIOLOGY

Much research has been done to find the underlying exact cause or etiology of metabolic

syndrome, but there are no complete studies on the main cause of metabolic syndrome. Therefore, it can be said that the underlying etiology of metabolic syndrome is multifactorial some of which are as follows: [9] (Figure 2).

Insulin Resistance

Metabolic syndrome is also commonly known as insulin resistance syndrome, and this term is used more rather than MetS. The beta cells in the pancreatic islets of Langerhans secrete the hormone insulin. Insulin and glucose mix under normal circumstances. It stimulates its uptake from circulation and takes it to the cells for glycolysis {series of reactions converting glucose to pyruvate or lactate with production of ATP} or is stored in the liver, muscle, or adipose as glycogen which is the storage form. These processes work simultaneously to maintain the blood glucose level at a normal level. In the case of Insulin resistance either there can be loss of insulin secretion in response to glucose which leads to Postprandial Hyperglycemia [PPG] (a condition in which blood glucose levels are abnormally high after eating a meal) or there can be exaggerated insulin response to glucose load leading to Chronic Hyperinsulinemia (a condition in which body has higher insulin level than normal level for longer duration of time).

Table 1. Definitions used for Metabolic Syndrome Diagnosis [8]

WHO 1999	NCEP ATP3 2005 (National Cholesterol Education Program)	IDF 2006 (International Diabetes Federation)
Presence of insulin resistance or glucose > 110mg/dl, 2 h glucose > 140 mg/dl, with occurrence of any two or more of the following: <ol style="list-style-type: none"> HDL cholesterol <35 mg/dl in men <40 mg/dl in women Triglycerides > 150 mg/dl Waist/Hip ratio >0.9 men & >0.85 women Or BMI > 30 kg/m² Blood Pressure >140 / 90 mmHg 	Occurrence of any three or more of the following: <ol style="list-style-type: none"> Blood glucose > 100 mg/dl or drug treatment for elevated glucose in blood HDL cholesterol <40 mg/dl in men <50 mg/dl in women or drug treatment for low HDL-C Blood Triglycerides >150 mg/dl or drug treatment for elevated triglycerides Waist >102 cm men > 88 cm women Blood Pressure >130/85 mmHg or drug treatment for hypertension 	Waist > 94 cm in men and >80 cm in women with the occurrence of two or more of the following: <ol style="list-style-type: none"> Blood glucose > 100 mg/dl or diagnosed diabetes HDL cholesterol <40 mg/dl in men <50 mg/dl in women or drug treatment for low HDL-C Blood Triglycerides >150 mg/dl or drug treatment for elevated triglycerides Blood Pressure >130/85 mmHg or drug treatment for hypertension

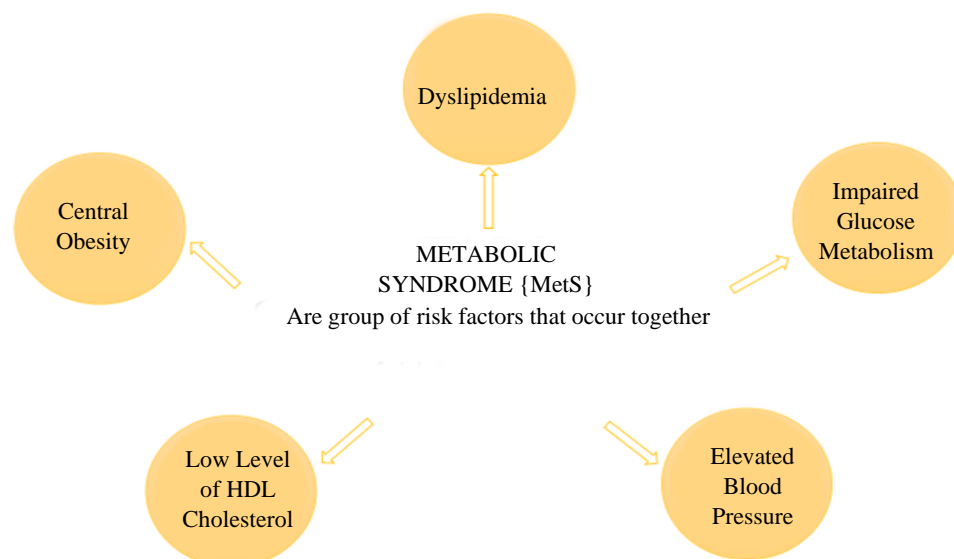


Figure 1. Causes of metabolic syndrome.

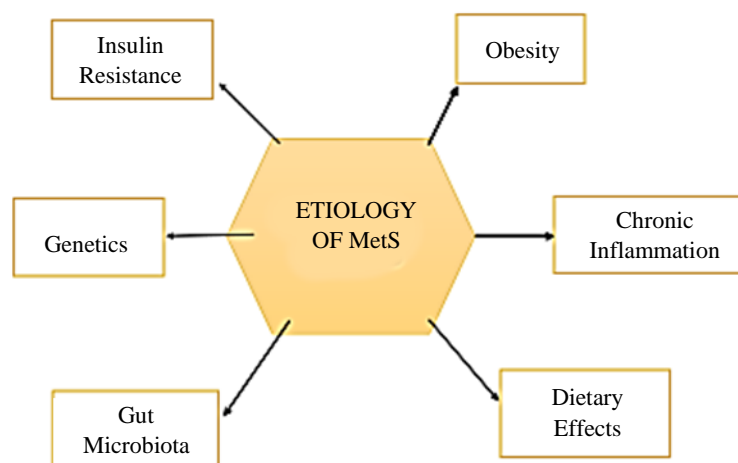


Figure 2. Etiology of metabolic syndrome.

The resistance of insulin from any of the above-mentioned ways can worsen over some time and there comes a time when the beta cells of the pancreas become fatigued and stressed leading to complete loss of their functions making the patients solely rely on insulin injections or drugs to bring down blood glucose level to normal.

Obesity

Excessive fat deposits that can harm health are the hallmark of obesity, a chronic complicated disease. Obesity affects bone health and reproduction, raises the risk of several malignancies, and increases the risk of heart disease and type 2 diabetes. According to the WHO, being obese affects one's ability to move and sleep. As it is defined above it can lead to or closely related chronic diseases such as CVD [cardiovascular disease], type 2 diabetes mellitus, nonalcoholic fatty liver disease (NAFLD) [in which fat builds up liver due to overweight or obesity not due to consumption of alcohol] and cancer. The absence of physical activity combined with overnutrition can lead to energy imbalance due to which the energy intake is more than the energy expenditure of a person ultimately resulting in fat storage in an obese individual. In the case of obese individual's leptin resistance can also happen, leptin is a hormone secreted by adipocytes and helps to send brain signals for termination of eating in case fat cells expand, it also regulates glucose homeostasis (the process by which the body maintains blood glucose levels), pancreatic beta cells as well as insulin-sensitive tissues.

Chronic Inflammation

If we simply define inflammation it is the body's defense mechanism through which the immune system recognizes the harmful and foreign stimuli and removes it from the body. Inflammation can be acute and chronic, acute inflammation is the first line of defense against infectious microorganisms and immunological stressors such as trauma, burn, and malignant growths (Gabay and Kushner, 1999; Haslett, 1992). Whereas chronic inflammation is an abnormal immune response that can last for months or years and is also referred to as slow, long-term inflammation according to the National Cancer Institute (NCI), [10-12]. The latter type of inflammation has been a characteristic feature in obesity, type 2 diabetes mellitus, cardiovascular diseases, and other metabolic syndrome-related diseases. When there are disturbances in the metabolic mechanism of the body it activates the immune system and cells in various tissues such as the adipose, liver, and pancreas. This also will lead to an increase in plasma inflammatory markers. Adipose is commonly known as fat storage but it also performs important functions as a powerful autocrine and endocrine organ, the adipose tissue macrophages are a key contributor to adipose inflammation and systemic inflammation. In fat accumulation, the fat cells secrete a group of hormones like adipokines and cytokines, which attract monocytes in circulation and enroll them in local adipose tissues then these monocytes differentiate into macrophages, infiltrating

adipose tissue especially surrounding the fat cells of adipose developing crown structures around them. Many studies have found that the local adipose inflammatory responses contribute to local insulin resistance and systemic inflammation.

Dietary Effects

One of the most important environmental factors for metabolic syndrome is nutrition in which overnutrition becomes the cause of many metabolic-related diseases. To improve health changing only a part of eating habits without making changes in overall nutrition cannot lead to significant health results. For instance, saturated and unsaturated fats have different results on insulin resistance and CVD complications, various studies found that PUFA and MUFA can lower the risk of CVD and have cardioprotective benefits. Similarly, Branched-chain amino acids BCAA also have benefits in the improvement of obesity and T2D, but their increased levels in circulation can also act as a marker of a lack of insulin activity. Polyphenols which are a dietary supplementation of plant origin can improve the disrupted glucose homeostasis due to insulin resistance and also exert a hypolipidemic effect [lowers the levels of lipids in the body] but the overdose of polyphenols can also cause serious issues.

Gut Microbiota

The human gastrointestinal (GI) tract consists of a community of microorganisms living in it, known as the gut microbiota and it offers many health benefits to the host such as maintaining gut integrity, digestion, regulating immunity, and protection against pathogens. In obese individuals, there has been an imbalance of gut microbiota. One of the important causes of a high-fat diet (HFD) inducing obesity is the disruption of the structure of gut microbiota causing inflammation due to consumption of HFD and is greatly promoted by lack of soluble fiber (that is inulin). Inulin is an important ingredient that helps prevent inflammation and metabolic syndrome by supporting microbiota-mediated intestinal tissue homeostasis. Supplementation through probiotics has shown its effect by improving and preventing diet-induced MetS. They also help in hypertension by improving lipid profile, regulation of insulin sensitivity, and bioconversion of bioactive isoflavones.

Genetics

Environmental surroundings can influence gene structure and functions and when these genetic factors interact with the environment, it contributes to metabolic syndrome MetS. It has also been put forward that parental epigenetic alterations can be transferred to the upcoming generation and thus reprogram the hepatic lipid metabolism of the offspring, contributing in particular to the development of non-alcoholic fatty liver disease (NAFLD) [13].

Risk Factors

Central/Abdominal Obesity

The accumulation of fat around the visceral area is associated with enlarged and dysfunctional adipose cells. These cells combine to form the dysfunctional adipose tissue, which secretes pro-inflammatory biomarkers such as C-reactive protein, cytokines, and prostaglandins. Adipose tissue also releases inflammatory mediators which contribute to the development of type 2 diabetes, hyperlipidemia, and CVD. In an individual if there is a higher ratio of fat to muscle it is most likely to contribute to metabolic dysfunction, this leads to increased free fatty acid in circulation which needs more insulin secretion for control of glucose metabolism. Consuming a diet rich in carbohydrates daily leads to postprandial hyperglycemia which results in acute inflammation that can later develop into chronic inflammation. Chronic systemic inflammation reduces metabolic flexibility and increases oxidative stress resulting in a vicious cycle of disease, depression, and inactivity, further contributing to metabolic syndrome. In the obese state, the other things that take place are, adipose tissue hypoxia which is associated with increased expression of a gene that causes inflammation, and decreased expression of adiponectin resulting in local as well as systemic inflammation in the individual, also there is increased leptin expression which modulates insulin resistance. One of the important things to note down is that not all people with obesity develop metabolic syndrome as some are metabolically healthy but are obese [14].

Dyslipidemia

Dyslipidemia is a condition in which the plasma has higher triglycerides and free fatty acid levels and is characterized by abnormalities of lipids which is an alternation in both types of lipoproteins that are atherogenic and antiatherogenic. This can also be caused by increased production of VLDL (very low-density lipoprotein), LDL (low-density lipoprotein), and decreased production of HDL (high-density lipoprotein). The condition in which the body is not able to produce a normal insulin response to a body glucose load is known as insulin resistance. It is a characteristic of MetS, which results in the development of type 2 diabetes mellitus. However, due to lifestyle patterns in the modernized world and increased obesity, there is an increased incidence of insulin resistance and type 2 diabetes with dyslipidemia and an increased risk of CVD. Cardiovascular disease risk is higher in individuals which has dyslipidemia due to lipid abnormalities with insulin resistance which is due to the disturbance in lipid metabolism. The liver plays an important role in lipid metabolism, the fatty acid is synthesized by the liver and also the dietary fatty acid is transported by chylomicron and plasma NEFA (non-esterified fatty acid) pool which originates from adipose tissue and are a source of hepatic lipid and VLDL triglycerides. In insulin resistance, the body's insulin fails to suppress the activity of enhanced lipolysis and flux of fatty acid. Simultaneously in liver triglyceride synthesis and storage increases and excess triglycerides are secreted as VLDL. Some studies done on insulin resistance and lipids have said that the development of a fatty liver requires insulin resistance since the pathway of hepatic acid biosynthesis is sensitive to increased levels of insulin. Low-grade inflammation characterized by obesity is one of the major sources of decreased insulin resistance. Obesity causes lipid accumulation in adipocytes, which ultimately activates other pathways responsible for the production of pro-inflammatory cytokines. Abdominal obesity coordinates with hyperinsulinemia (high amount of insulin in the blood) which increases hepatic VLDL synthesis and exhibits high triglycerides. [15] (Figure 3).

MANAGEMENT

Some ways through which metabolic syndrome can be managed are as follow: [16]

Physical Activity

A sedentary lifestyle characterized by physical inactivity and increasing obesity has become the main reasons for the cause of metabolic syndrome. Numerous studies have shown an interconnection between obesity, physical inactivity, and metabolic syndrome with a sedentary lifestyle (it is a type of lifestyle including sitting or lying down with office or computer work or watching television with no physical activities. Abdominal obesity can be reversed and reduction in obesity has a beneficial effect in reducing CVD and MetS risks. Exercise or physical activity is beneficial to an individual in many ways whether they are obese or not. One of anti-inflammatory effects of exercise is that it helps in reducing adipose tissue hypoxia resulting in improved capillary blood flow. Additionally, exercise improves glucose tolerance, insulin resistance, and lipid metabolism while also lowering blood pressure. There are no specific guidelines established regarding how much exercise an individual has to do but many programs were developed from different studies. For example, the American College of Sports Medicine (ACSM) has suggested that 150 to 250 minutes of moderate-intensity exercise per week is optimum, while others have suggested that 30 to 60 minutes per day is necessary. There is also a general consensus that performing 30 minutes of activity per day or taking 3000 steps per day beyond the normal daily activities of an individual is sufficient to improve overall health status [14].

Probiotics

Modifications in the composition of the gastrointestinal microbiome can lead to the development of insulin resistance with obesity. The gastrointestinal (GI) microbiota is the set or group of microorganisms residing in the GI tract of humans, primarily in the colon (a part of the large intestine). More than 90 percent of them belong to only two bacterial domains (out of 70 known)- Bacteroides and Firmicutes. Studies comparing normal-weight individuals and obese individuals have shown that obese individuals have a reduced ratio of Bacteroidetes/Firmicutes [17]. Many studies have indicated that low gastrointestinal microbiota can have undesirable effects on dyslipidemia, inflammatory markers,

adiposity, and insulin resistance [18]. It has been postulated that low microbial gene richness is a good marker for metabolic syndrome and that the inclusion of probiotics may improve some of the clinical components of metabolic syndrome. According to FAO/WHO Expert Consultation 2001, Probiotics are defined as the bacteria associated with beneficial effects for humans and animals. However, the most widely accepted definition describes probiotics as "live microorganisms, which when consumed in adequate amounts, confer a health effect on the host." Results regarding the inclusion of probiotics in the treatment of metabolic syndrome (MetS) have been conflicting and this inconsistency is likely due to the diverse doses, strains, and study designs [19]. Therefore, more studies are needed to know the beneficial effects of probiotics and their mechanism of action on metabolic syndrome.

Functional Foods

Food that offer beneficial health benefits beyond their fundamental nutritional contents are known as functional foods. They may be complete food or they may be fortified, enriched or improved with probiotics, phytochemicals, dietary fiber, minerals or other elements (Table 2).

Dietary Patterns

Diet is the most crucial part of metabolic syndrome and our lifestyle [4]. Common dietary intervention that focuses on a single nutrient can have several limitations. For effectively treating metabolic syndrome, the main focus should be on overall dietary patterns instead. The goals of management by dietary pattern should aim at reducing abdominal fat or obesity, improving insulin resistance, maintaining stable blood sugar levels, and decreasing inflammation in the body. Diverse types of dietary patterns are followed and shown beneficial effects in the management of metabolic syndrome, such as Mediterranean diet, DASH diet, ketogenic diet, plant-based diet, etc. But, before knowing the different types of diets there are a few key concepts that should be focused on diet management of metabolic syndrome (Figure 4).

TYPES OF DIETARY PATTERNS

Mediterranean diet (Med Diet)

It is a plant-based diet with a high intake of vegetables primarily green leafy vegetables, fruits, whole grain cereals, pulses together with legumes, nuts, and extra virgin cold pressed olive oil (also known as EVOO). Mediterranean diet is not just a "diet pattern" but also the culture and culinary technique fixed to the country and the people living Mediterranean region. This approach emphasizes a high-fat and low-carbohydrate diet, supplying 35% to 45% of energy from fats, 15% from proteins, and 40% to 45% from carbohydrates per day.

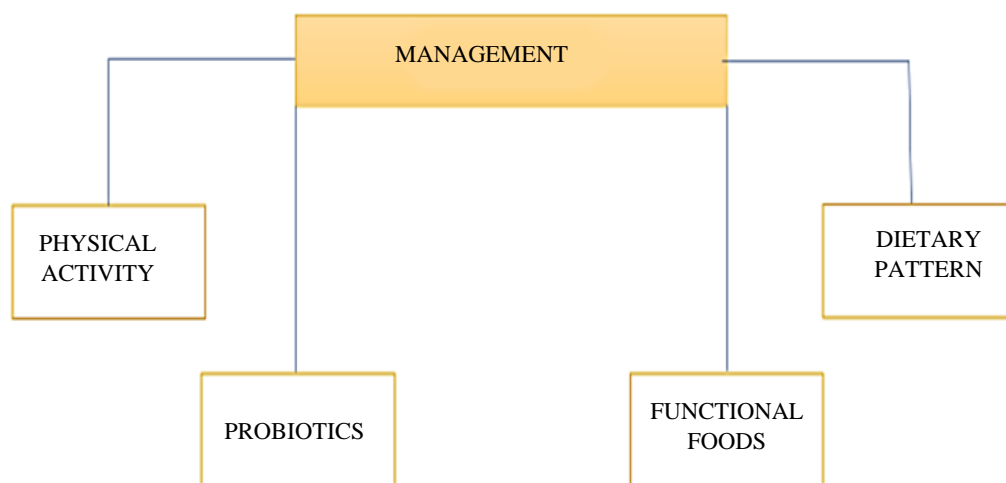


Figure 3. Management of Metabolic Syndrome.

Table 2. Role of functional food in management of metabolic syndrome.

Functional Foods	Their Effect on Different Components of Mets
Green Tea	<ul style="list-style-type: none"> ↓ Body weight, Body fat and Waist circumference ↓ Blood pressure ↓ Cholesterol, Triglycerides, LDL-C ↑ HDL-C
Garlic	<ul style="list-style-type: none"> ↓ Systolic and diastolic blood pressure Anti-inflammatory effect (from organosulfur compounds) Antioxidant action (due thiol group) Antithrombotic effect → Insulin sensitivity
Ginger	<ul style="list-style-type: none"> ↓ Systolic blood pressure Anti- inflammatory effect
Onion	<ul style="list-style-type: none"> ↓ Blood pressure ↓ Cholesterol ↓ Insulin resistance Anti- inflammatory effect and antioxidant action
Omega-3 Fatty acid (EPA, ALA and DHA)	<ul style="list-style-type: none"> ↓ Adipose tissue mass Beneficial on systolic and diastolic blood pressure ↓ Cholesterol, Triglycerides, LDL-C ↑ HDL-C
Cinnamon (Cinnamomum verum)	<ul style="list-style-type: none"> ↑ insulin sensitivity Regulates blood glucose and blood pressure Antithrombotic effect Antioxidant action Anti-inflammatory effects
Neem (Azadirachta indica)	<ul style="list-style-type: none"> ↑ Insulin secretion ↑ glucose tolerance (through reduction of intestinal and pancreatic glucosidase activity) Improves post-prandial hyperglycaemia
Ginseng	<ul style="list-style-type: none"> ↓ Body weight ↑ Insulin ↓ Fasting glucose and HbA1c ↓ Cholesterol, LDL-C Suppression of HMG-CoA reductase Suppression of Cholesterol 7 alpha- hydroxylase
Cumin (Cuminum cyaminum)	<ul style="list-style-type: none"> ↓ Lipid levels ↓ glycemia
Fish Oil (omega fatty acid)	<ul style="list-style-type: none"> ↓ Lipogenesis ↑ fatty acid oxidation (in liver and adipose tissue)
Grapes (Vitis vinifera)	<ul style="list-style-type: none"> ↓ adipogenesis ↑ lipolysis Antioxidant action Enhances insulin sensitivity, glucose tolerance
Citrus bergamia	<ul style="list-style-type: none"> ↓ Cholesterol, Triglycerides and LDL-C ↑ HDL-C
Pomegranate	<ul style="list-style-type: none"> ↓ Blood pressure ↓ Systolic blood pressure

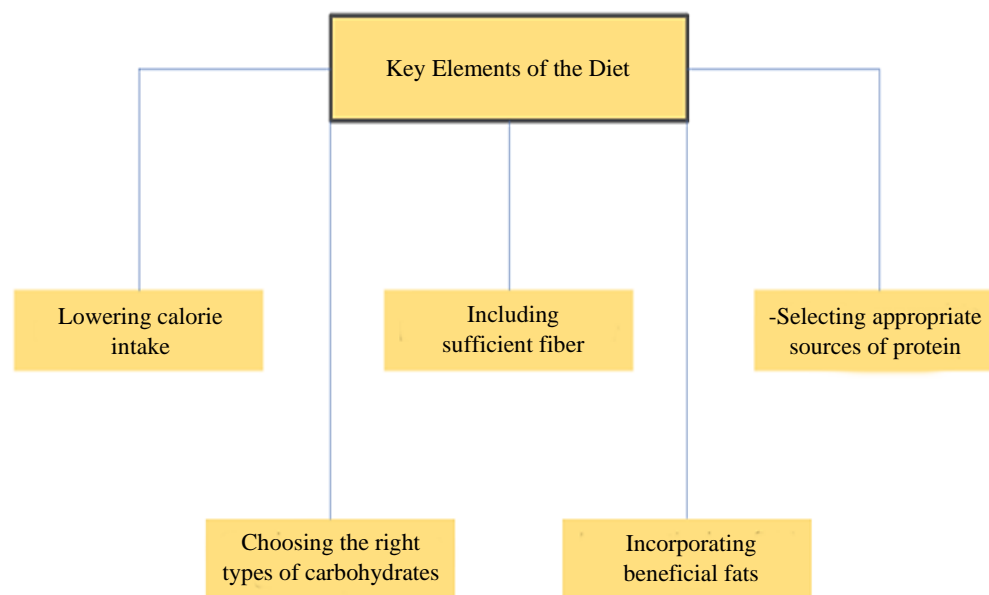


Figure 4. Key Elements of the Diet.

The main source of fats in this diet is EVOO (i.e. Extra Virgin Olive Oil) which is a source of monounsaturated fatty acids (MUFA) and nuts. The intake of MUFA helps in the improvement of insulin resistance and lipid profile, and controlling both systolic and diastolic blood pressure. With this, EVOO is also a rich source of polyphenols helping in anti-inflammatory and anti-oxidant effects. The diet consists of increased consumption of fruits and vegetables, which has many nutritional benefits, for example, many are sources of antioxidant - vitamins {Vitamin C, E, and beta carotene}, phytochemicals, folate, and minerals. The diet has been recognized by UNESCO as an Intangible Cultural Heritage of Humanity [21] and by the American Dietary Guidelines as a healthful dietary pattern [22].

Dash diet [Dietary Approach to Stop Hypertension]

The DASH diet is a type of dietary pattern rich in whole cereals, low-fat/ fat-free dairy products, legumes, nuts, fruits, and vegetables. It restricts the consumption of processed or red meat, as well as sugary drinks. The diet in 1997, has been recognized for its potential to help manage or treat hypertension (high blood pressure). The DASH diet is also distinguished by its low-fat content, accounting for 27% of daily kcal intake, particularly including saturated fatty acids and cholesterol from the diet (150 mg per day approx.), and decreased sodium intake (1500 mg to 2300 mg per day).

The DASH diet is highly rich in fibre and important electrolytes such as potassium, calcium, and magnesium, compared to other dietary patterns. This intervention not only shows its benefit in reducing high BP but also has effects against abdominal obesity and increased body weight. It shows its effect by a reduction in BMI, waist circumference as well as weight loss. These health benefits are mainly due to the diet being rich in fruits and vegetables, high fibre intake, rich in nutrients, and limited in sodium and fat.

Plant-Based Diet

A plant-based diet is an umbrella term used for various types of diets based on plant-sourced food intake and reduction/ restriction of animal-derived food.

Some of the plant-based diets are:

- Strict Vegetarian diet – This diet excludes all animal-derived foods, including meat, poultry, seafood, dairy products, eggs, and honey.

- Lacto-vegetarian diet- In this diet, all animal-based foods are restricted, with the exception of dairy products.
- Lacto-ovo-vegetarian diet- This diet excludes meats seafood and poultry but includes dairy products and eggs.
- Pescatarians – Also known as pesco-vegetarians, this diet is similar to lacto-ovo-vegetarians but includes the consumption of fish and seafood.

Plant-based diets have many beneficial effects including a reduction in risk of Type 2 diabetes mellitus, cardiovascular diseases, and also cancer.

Even though the diet is vegetarian, it doesn't entirely suggest a 'healthy dietary pattern', it can include intake of sugary foods and beverages. For the beneficial effect of this dietary pattern, the person has to follow a nutritious plant-based diet which is characterized by the consumption of whole cereals, legumes, fruits, vegetables, and non-HVOs (non-hydrogenated vegetable oils).

Low-CH Diet (Ketogenic Diet)

This diet is described as a decrease in the carbohydrate (CH) intake of less than 10% of daily energy consumption that is 30g to 50g of carbohydrates per day and also an increase in fat consumption.

In the Ketogenic diet, there is a limitation on the consumption of highly processed foods, refined cereals, starches, and food that is rich in simpler sugar/ additional sugar. This type of restrictive approach has shown various beneficial effects in obesity and cardiovascular diseases through decreasing body weight and improving lipid panels. The benefits of a low-carbohydrate diet, (such as a ketogenic diet), lie in its ability to prevent the rapid absorption of some carbohydrates, like glucose or refined cereals. Ketogenic diets have revealed a restorative role in multiple NCDs (Non-communicable diseases) which include obesity/ overweight, cardiovascular diseases, and metabolic syndrome. The absence of dietary carbohydrates in the diet leads to a decrease in insulin secretion resulting in disturbed lipogenesis, and fat accumulation and leading to an upsurge in the breakdown of storage fats. Carbohydrate limitation and glycogen insufficiency are the characteristics of low carbohydrate diets resulting in the usage of ketone bodies as the primary source of energy. Energy limitation is also necessary to manage ketone body production in the body.

Current studies have also shown, that these type of diets benefits in the reduction of body weight and cardiovascular diseases due to energy limitation. However, there are also difficulties due to the absence of whole grains, fruits, and vegetables in the ketogenic diet.

High Protein Diet

This dietary approach is illustrated by taking 20% to 30% daily energy from protein which is 1.34g to 1.5g protein per kilogram of body weight. Analyses have also shown that high protein diets lead to a reduction in body weight and improvement in cardiovascular diseases than a common protein diets, and high protein diets are also used for the cure of obesity, metabolic syndrome, and glycaemic management.

Patients who followed a high protein diet have shown a significant result in the reduction of triglyceride levels, and weight reduction in obese individuals. The mechanism of health benefits of a high protein diets is due that protein induces satiety, which results in reduced energy intake in the next meal. A high protein intake diet also eliminates loss of muscle mass during an energy resistance dietary approach at the time of weight loss. The dietary guideline recommended placing importance more on plant-based sources of proteins such as legumes, soy, beans, nuts, and seeds rather than animal-based sources of proteins such as meat or processed meat products. The animal-based sources of proteins are also linked with a high risk of developing type 2 diabetes mellitus, cardiovascular diseases, and metabolic syndrome, whereas the plant-based sources of proteins are richer in fibre, phenolic

substances, and Poly Unsaturated Fatty Acids (PUFA) with cholesterol or Saturated Fatty Acids (SFA) in lesser composition. (Table 3).

Other dietary patterns include:

- Low-fat diet
- Nordic diet
- Intermittent fasting

Table 3. Benefits of different dietary patterns on metabolic syndrome.

Dietary patterns	Distribution of nutrients	Benefits
Mediterranean diet [Plant- based diet]	<ul style="list-style-type: none"> • 40-45% energy from carbohydrates • 15-18% energy from proteins • 35-45% energy from fat (MUFA, EVOO and Nuts) 	<ul style="list-style-type: none"> • Reduction of blood pressure • Decreased incidence of CVD • Improved blood lipid profile • Betterment of insulin resistance [decreased incidence of T2DM]
DASH diet	<ul style="list-style-type: none"> • 55% energy from carbohydrates • 18% from protein • Reduced sodium content • 27% from total fat (From which 6% kcal/d should come from saturated fats) 	<ul style="list-style-type: none"> • Reduction of both systolic and diastolic blood pressure • Reduced incidence of T2DM • Reduction in BMI and waist circumference as well as weight
Plant-based diet	<ul style="list-style-type: none"> • Total reduction or restriction of animal food or products • Intake of purely healthy plant-based food sources 	<ul style="list-style-type: none"> • Reduced risk of obesity and body weight • Decreased risk of CVD and T2DM • Reduced in blood pressure
Ketogenic diet or Low carbohydrate diet	<ul style="list-style-type: none"> • Less than 10% of energy from carbs in ketogenic diet and <50% in low carbohydrate diet • High protein – 20% to 30% energy • High fat – 30% - 70% energy 	<ul style="list-style-type: none"> • Weight loss and maintenance • Improved insulin resistance • Control of Hb1Ac levels • Decreased LDL-c and triglyceride levels
Low fat diet	<ul style="list-style-type: none"> • 50%-60% energy from carbs • 15- 17% from protein • <30% kcal/d from total fat in which <10% of saturated fat 	<ul style="list-style-type: none"> • Weight loss of short term • Reduced risk of mortality • Decreased blood pressure • Improvement of cholesterol profile but for short term
High Protein diet	<ul style="list-style-type: none"> • 40-50% kcal/day energy from carbohydrate • 20-30% kcal/day from protein or 1.3 to 1.5 g of protein/ Kg of body weight daily. 	<ul style="list-style-type: none"> • Decrease in triglycerides level
Nordic Diet	<ul style="list-style-type: none"> • Less amount of meat and processed foods in diet • High amount of whole meal fiber and by-products. 	<ul style="list-style-type: none"> • Decrease in systolic and diastolic blood pressure • Increase levels of HDL-C levels
Intermittent fasting	<ul style="list-style-type: none"> • Long period time of fasting 	<ul style="list-style-type: none"> • Improvement in insulin resistance and dyslipidemia • Reduction in weight and both blood pressure • Decreases the risk of type 2 diabetes and cardiovascular diseases

CONCLUSION

Metabolic syndrome (MetS) is a clinical condition characterized by the presence of a group of risk factors when at least three of these occur jointly. Each of these risk factors is influenced by an individual's lifestyle and dietary practices. The lifestyle approaches of a population can greatly impact its overall health. For instance, a population with high rates of consumption of tobacco, alcohol, and opium tends to have a higher risk of developing metabolic syndrome and associated health issues. In comparison, the populations that have a healthier lifestyle, which includes proper physical activity and balanced dietary practices—focusing on overall nourishment rather than focusing on a single nutrient—have displayed a reduced risk of MetS and health-related problems.

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