Prevention and nutritional therapy of metabolic syndrome

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ABSTRACT

The term metabolic syndrome (MetS) defines the co-occurrence of the related risk factors of metabolic origin that promote the development of cardiovascular diseases with atherosclerotic background and type 2 diabetes. The diagnostic criteria of MetS have undergone modifications for years. Until now no clear definition of MetS has been established. The latest diagnostic criteria of MetS published in 2009 by a group of IDF (International Diabetes Federation) and AHA/NHLBI (American Heart Association/ National Heart, Lung and Blood Institute) experts discern three out of five risk factors: abdominal obesity (taking into consideration population differences), elevated level of triglycerides, reduced HDL cholesterol, hypertension and fasting hyperglycemia. Genetic predispositions and environmental factors, such as lack of physical activity and improper diet are considered to be responsible for MetS development. Therefore, prevention and treatment of MetS should be based first of all on a change in modifiable lifestyle factors, among which proper diet is of essential importance.
Keywords: metabolic syndrome, obesity, blood pressure, dyslipidemia, hyperglycemia

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DEFINITION AND DIAGNOSTIC CRITERIA OF METABOLIC SYNDROME

In medicine, reports on the so called X syndrome – a metabolic syndrome (MetS) appeared already in the middle of the 20th century. However, it is Gerald Reaven who was the first to define in 1988 the main MetS components to be insulin resistance, hyperinsulinemia, impaired glucose tolerance, hypertension and dyslipidemia [1].

In 1998, WHO (World Health Organization) issued a definition [2], according to which MetS can be identified only when one of the following risk factors occurs:

- Diabetes mellitus type 2 (fasting glucose ≥126 mg/dl or glycaemia two hours after glucose load ≥200 mg/dl);
- Impaired glucose tolerance (IGT) (fasting glucose 110-125 mg/dl and glycaemia 2 hours after glucose load ≥140 mg/dl);
- Impaired fasting glucose (IFG) (fasting glucose 110-125 mg/dl and glycaemia 2 hours after glucose load ≥140 mg/dl);
- Insulin resistance (IR) (glucose uptake below the lowest quartile for background population investigated under hyperinsulinemic-euglycaemic conditions).
- Two out of four risk factors were considered an additional criterion:
- Abdominal obesity (waist-hip ratio WHR ≥0.9 for men and≥0.85 for women and/or body mass index BMI ≥30 kg/m^2);
- Dyslipidaemia (triglycerides ≥150 mg/dl and/or HDL cholesterol <35 mg/dl for men and<39 mg/dl for women);
- Arterial blood pressure (≥140/90 mm Hg and/or controlled hypertension);
- Microalbuminuria (urinary albumin excretion ≥20 μg/min or albumin/creatinine ratio ≥30 mg/g).

WHO definition took into account MetS pathogenesis, i.e. insulin resistance. However, MetS diagnosis should be simple and commonly available, whereas WHO criteria required specialist diagnostic examinations, thus limiting their application.

The European Group for the Study of Insulin Resistance (EGIR) [3] modified the WHO criteria; however, the indispensable condition was still insulin resistance (plasma insulin >75 percentile).

Additional criteria (2 out of 4) included:

- Abdominal obesity (≥94 cm for men and ≥80 cm for women);
- Dyslipidaemia (triglycerides ≥150 mg/dl and/or HDL cholesterol <39 mg/dl for men and women);
- Arterial blood pressure (≥140/90 mm Hg and/or controlled hypertension);
- Fasting glycaemia (≥110 mg/dl, IGF, IGT, but not diabetes).

The modification of MetS diagnostic criteria was issued in 2001 in the Third Report of National Program of Cholesterol Education NCEP-ATP III (National Cholesterol Education Program, Adult Treatment Panel III) [4,5]. These new criteria differed in the lack of insulin resistance as an indicator of MetS, which made them more suitable for every day clinical practice. In the NCEP-ATP III definition, all the risk factors of MetS were equivalent and to diagnose MetS three out of five factors had to be met:

- Abdominal obesity (≥102 cm for men and≥88 cm for women);
- Level of triglycerides (≥150 mg/dl);
- Level of HDL cholesterol (<40 mg/dl for men and<50 mg/dl for women);
- Arterial blood pressure (≥130/85 mm Hg);
- Fasting glucose (≥110 mg/dl or diabetes).

However, NCEP-ATP III criteria in the diagnosis of MetS also had some limitations. The threshold values of abdominal obesity in the NCEP-ATP III criteria were established on the basis of the National Institute of Health as the main quartile for the USA population and did not take into account race or ethnic differences.

In 2003, the American Society of Clinical Endocrinologists (AACE) [6] again proposed the criteria with insulin resistance as the leading factor. The prerequisite for MetS diagnosis was:

- IGT or IGF, but not diabetes.
- Moreover, an additional factor was one of the following:
- Overweight or obesity (BMI ≥25 kg/m^2);
- Dyslipidaemia (triglycerides ≥150 mg/dl and/or HDL cholesterol <40 mg/dl for men and <50 mg/dl for women);
- Arterial blood pressure (≥130/85 mm Hg);
- - Other risk factors: positive family history of type 2 diabetes, polycystic ovarian syndrome, sedentary lifestyle, old age, being part of the ethnic group exhibiting high risk for developing type 2 diabetes.

However, diagnostic recommendations of AACE are not commonly applied due to the lack of precise criteria. In 2005, the International Diabetes Federation (IDF) presented new diagnostic criteria of MetS [7]:

- Abdominal obesity (waist measurement ≥94 cm for men and ≥80 cm for women in the European population or BMI ≥30 kg/m^2);
- Additionally, at least two out of four factors have to occur:
- Triglycerides (≥150 mg/dl) or management of hypertriglyceridemia;

- HDL cholesterol (<40 mg/dl for men and <50 mg/dl for women) or treatment of low HDL-C;
- Arterial blood pressure (systolic ≥130 and/or diastolic ≥85 mm Hg, or treatment of arterial hypertension);
- Fasting glucose (≥100 mg/dl or treatment of diabetes).

Insulin resistance, which is difficult to identify in everyday medical practice, was not taken into consideration. However, abdominal obesity by ethnic group, which is closely associated with the occurrence of insulin resistance, was accepted as a criterion. In the IDF definition, the lower limit of abnormal fasting glucose level was reduced from 110 mg/dl to 100 mg/dl. Due to simplicity of the diagnostic criteria presented by IDF, the definition is frequently used in epidemiological studies [8].

In 2009, IDF and AHA/NHLBI (American Heart Association/ National Heart, Lung and Blood Institute) [9] accepted common criteria for the diagnosis of MetS, according to which the metabolic syndrome is diagnosed when at least three out of five risk factors are identified (table 1). In the presented criteria, abdominal obesity is not a prerequisite for the diagnosis of the metabolic syndrome. Abdominal obesity depending on the different population and ethnic group, for example in the European population recommendations for the waist circumference are ≥94 cm for men and ≥80 cm for women; in the USA population ≥102 cm for men and ≥88 cm for women; in the Asian population ≥90 cm for men and ≥80 cm for women.

Table 1. Current criteria for clinical diagnosis of the Metabolic Syndrome [9].

Measure	**Categorical cut points**
Elevated waist circumference	Population- and country-specific definitions
Elevated triglycerides or drug treatment for elevated triglycerides	≥150 mg/dl (1,7 mmol/l)
Reduced HDL cholesterol or drug treatment for reduced HDL cholesterol	<40 mg/dl (1,0 mmol/l) for men, <50 mg/dl (1,3 mmol/l) for women
Elevated blood pressure or antihypertensive drug treatment	systolic ≥130 and/or diastolic ≥85 mm Hg
Elevated fasting glucose or drug treatment of elevated glucose	≥100 mg/dl

Currently, no definition can be totally rejected. Further prospective, randomized epidemiological and clinical studies are needed. Additionally, other symptoms and disorders that go beyond the scope of the definition are observed in MetS, which for practical reasons should be individually identified. However, the finding of any MetS component is a prerequisite for diagnostic performance to diagnose or exclude all other disorders.

EPIDEMIOLOGY

The incidence of MetS in Poland and worldwide increases each year, despite taking into account different diagnostic criteria. Research conducted in Poland shows that approximately 20% of the adult population suffer from MetS, and that more frequently women are affected. Worldwide, this problem affects even 33% of the USA population, 27% of the population of China and in Europe - 15% of the population of France and up to 34% of the Italian or Finland population [10].

The major cause of MetS is abdominal obesity, which subsequently leads to type 2 diabetes and cardiovascular disorders, and contributes to the increased mortality due to complications. In the USA, over 25% of adult inhabitants are affected [11]. Worldwide, in 2014 overweight was diagnosed in 39% of the population (38% of men and 40% of women) above the age of 18, whereas obesity in 13% (11% of men and 15% of women). Moreover, 41 million of children under 5 years of age had overweight or obesity. Between 1980 and 2014 the world incidence of obesity increased twice [12].

PREVENTION AND NUTRITIONAL THERAPY OF THE METABOLIC SYNDROME

The metabolic syndrome is a complex disease. Therefore, prevention and treatment also have to be multifaceted and involve not only the institution of dietetic management and increased physical activity, but also pharmacotherapy to rebalance lipid parameters, glycaemia and arterial blood pressure [13].

Body mass normalization plays a major role [14]. Body mass reduction should be gradual and should involve a 10% drop within a year, resulting in a decrease in dietary energy value by 500-1000 kcal/day. The diet should be based on easily digestible carbohydrates with low or moderate glycaemic index (<70) and low glycaemic load (<10), accounting for 50% of daily dietary energy

value. The intake of simple sugars contained in sweets, cakes and honey has to be limited (below 10% of dietary energy value). Dietary carbohydrates are obtained from wholegrain cereal products, vegetables and fruit, legume seeds and nuts, which also provide fibre, group B vitamins, polyphenols and mineral components. The content of dietary fibre in a reducing diet should oscillate around 30-40 g/day. Clinical examinations showed that a low-glycaemic index diet improves glycaemia control in diabetes [15]. The glycaemic index of food products is determined by the degree of grinding and boiling (the higher the degree, the higher the glycaemic index), the presence of other nutrients in food (fibre, protein and fats reduce the glycaemic effect of carbohydrates), the effect of the preceding food product (low glycaemic index meal may reduce glycaemia after the consumption of a subsequent meal) [16].

The quantitative dietary content of fat should account for 30% of energy intake available from food; however, also the quality of fats has to be considered. The recommended consumption of monosaturated fatty acids should constitute 10-15% of energy intake, polyunsaturated fatty acids 6-10%, including omega-6 fatty acids (5-8%) and omega-3 fatty acids (1-2%), whereas saturated fatty acids should be limited to 7%. Moreover, the intake of trans type fatty acids should be as low as possible, not exceeding 1% of dietary energy value. Dietary cholesterol content should be no more than 200-300 mg/day. The best food sources of fat for patients with MetS include vegetable virgin oils, cold-pressed and eaten raw, as well as nuts (especially walnuts) and saltwater fish rich in omega-3 fatty acids. The intake of animal fats and hard margarines has to be limited. It has been demonstrated that the use of energy-low diet with modified proportion of polyunsaturated fatty acids (n-3/n-6; 1:4-6) for 12 weeks reduces lipid metabolism disorders and arterial blood pressure in obese patients with clinical symptoms of the metabolic syndrome [17].

The dietary protein intake should account for 20% of dietary energy, with the 50/50% of animal to vegetable protein ratio. Low-fat poultry, low-fat dairy products, especially fermented milk drinks, fish, eggs, legume seeds and wholegrain cereal products are a good source of dietary protein.

Dietary salt consumption should not exceed 5g, as excessive salt intake causes hypertension and leads to treatment-resistant hypertension. Therefore, all highly-processed salt-rich products, such as salty snacks, fast food, powdered soups and sauces, spice mixtures, smoked cheese and meat have to be eliminated from the diet [18,19].

Plant polyphenols are an important dietary component, which in the Polish diet is mainly available from coffee, tea, vegetables and fruit. It has been demonstrated that the consumption of polyphenols in the Polish diet is inversely correlated with the presence of MetS and the risk of hypertension [20,21].

The consumption of 5-6 small-volume meals daily are recommended, taking into account food preferences of patients, and 1.5 litre of low-sodium water. Regular physical activity (30-45 min daily) is of utmost importance [22].

CONCLUSIONS

MetS prevention and therapy in the first place should involve non pharmacological methods, such as proper diet and physical activity, which lead to body mass reduction and restrict the occurrence of risk factors.

Conflicts of interest

The authors declare that they have no conflict of interest.

REFERENCES

1. Reaven GM. Role of insulin resistance in human disease. Diabetes 1988 Dec;37(12):1595-607.
2. Alberti KG, Zimmet PZ. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. Diabet Med 1998 Jul;15(7):539-53.
3. Balkau B, Charles MA. Comment on the provisional report from the WHO consultation. European Group for the Study of Insulin Resistance (EGIR). Diabet Med. 1999 May; 16(5):442-43.
4. Executive summary of the third report of The National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III). JAMA 2001 May; 285(19):2486-97.
5. Third report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III) Final Report. Circulation 2002 Dec;106:3143.
6. Einhorn D, Reaven GM, Cobin RH, Ford E, Ganda OP, Handelsman Y, Hellman R, Jellinger PS, Kendall D, Krauss RM, Neufeld ND, Petak SM, Rodbard HW, Seibel JA, Smith DA, Wilson PW. American College of Endocrinology position statement on the insulin resistance syndrome. Endocr Pract 2003 May-Jun;9(3):237-52.
7. Alberti KG, Zimmet P, Shaw J. Metabolic syndrome – a new world-wide definition. A consensus statement from the International

Diabetes Federation. Diabet Med 2006 May;23(5):469-80.
8. Grosso G, Stepaniak U, Micek A, Stefler D, Bobak M, Pająk A. Dietary polyphenols are inversely associated with metabolic syndrome in Polish adults of the HAPIEE study. Eur J Nutr 2017 Jun;56(4):1409-20.
9. Alberti KG, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, Fruchart JC, James WP, Loria CM, Smith SC Jr; International Diabetes Federation Task Force on Epidemiology and Prevention; Hational Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; International Association for the Study of Obesity. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. Circulation 2009 Oct 20;120(16):1640-5.
10. Kalinowski P, Mianowana M. Metabolic Syndrome part II: Epidemiology of metabolic syndrome in Poland and in the world. J Educ Health Sport 2016;6(4):466-80.
11. Ford ES, Giles WH, Mokdad AH. Increasing prevalence of the metabolic syndrome among U.S. adults. Diabetes Care 2004 Oct;27(10): 2444-9.
12. The World Health Statistic 2015 Available from: http://www.who.int/gho/publications/world_health_statistics/2015/en/
13. Ohbu-Murayama K, Adachi H, Hirai Y, Enomoto M, Fukami A, Obuchi A, Yoshimura A, Nakamura S, Nohara Y, Nakao E, Umeki Y, Fukumoto Y. Ezetimibe combined with standard diet and exercise therapy improves insulin resistance and atherosclerotic markers in patients with metabolic syndrome. J Diabetes Investig 2015 May;6(3):325-33.
14. Echeverría G, McGee EE, Urquiaga I, Jiménez P, D'Acuña S, Villarroel L, Velasco N, Leighton F, Rigotti A. Inverse associations between a locally validated Mediterranean diet index, overweight/obesity, and metabolic syndrome in Chilean adults. Nutrients 2017 Aug 11;9(8). pii: E862.
15. Thomas D, Elliott EJ. Low glycaemic index, or low glycaemic load, diets for diabetes mellitus. Cochrane Database Syst Rev 2009 Jan 21;(1): CD006296.
16. Nazare JA, de Rougemont A, Normand S, Sauvinet V, Sothier M, Vinoy S, Dėsage M, Laville M. Effect of postprandial modulation of glucose availability: short and long-term analysis. Br J Nutr 2010 May;103(10):1461-70.
17. Pałkowska E, Bartnikowska E, Owsiak D. The use of low-caloric diet with modified fatty acids pool in the therapy of the metabolic syndrome. Rocz Panstw Zakl Hig 2012;63(2):163-9.
18. Tykarski A, Narkiewicz K, Gaciong Z, Januszewicz A, Litwin M, Kostka-Jeziorny K. Zasady postępowania w nadciśnieniu tętniczym – 2015 rok. Nadciśnienie Tętnicze w Praktyce. Via Medica 2015;1(1):1-70.
19. Grupa Robocza Europejskiego Towarzystwa Kardiologicznego (ESC) i Europejskiego Towarzystwa Miażdżycowego (EAS) do spraw leczenia zaburzeń lipidowych. Wytyczne ESC/EAS dotyczące leczenia zaburzeń lipidowych w 2016 roku. Kardiol Pol 2016; 74(11):1234-318.
20. Grosso G, Stepaniak U, Micek A, Stefler D, Bobak M, Pająk A. Dietary polyphenols are inversely associated with metabolic syndrome in Polish adults of the HAPIEE study. Eur J Nutr 2017 Jun;56(4):1409-20.
21. Grosso G, Stepaniak U, Micek A, Kozela M, Stefler D, Bobak M, Pajak A. Dietary polyphenol intake and risk of hypertension in the Polish arm of the HAPIEE study. Eur J Nutr 2017 May 4.
22. Narayanappa S, Manjunath R, Kulkarni P.Physical activity patterns and its influence on risk factors for metabolic syndrome among an urban working population. Int J Med Sci Public Health 2016;5(6):1275-81.