REVIEW PAPER

DOI: https://doi.org/10.20883/jms.2018.259

The criteria of the identification of metabolic obesity among people with normal body weight and their use in everyday practice

Katarzyna Pastusiak, Juliusz Przysławski

Chair and Department of Bromatology and Human Nutrition, Poznan University of Medical Sciences, Poznan, Poland

ABSTRACT

Obesity and the metabolic syndrome caused by it constitute one of the biggest health issues of the 21st century. However, a problem of "a concealed form of obesity" — metabolic obesity with a normal body weight, which manifests clinically through the occurrence of metabolism disorders related to obesity among people with a normal body mass index — was pointed out in the 1980s. This affliction entails similar health consequences and causes many more problems in diagnosis and early treatment because a lack of obesity does not make doctors search for the traits of metabolic syndrome among seemingly healthy patients. The aim of this study is to present a proposition of diagnostic criteria for this disease in the historical perspective and to consider the possibilities of their use in everyday clinic practice.

Keywords: metabolically obese normal weight, metabolic syndrome, diagnostic criteria

Introduction

The obesity and metabolic syndrome related to it constitute one of the biggest health threats of the 21st century. For many centuries, researchers have been searching for the reason for this issue and, first of all, for effective treatment methods. However, it was noticed in the 1980s that excessive body mass cannot be a basis for the development of all troubles related to metabolic syndrome. A concept of a metabolically obese normal weight (MONW) was created. This occurs among people with an appropriate Body Mass Index (BMI) value and is typified by a combination of metabolism disorders characteristic for obese people with metabolic syndrome. Taking into consideration the fact that in the population of "healthy people", the percentage of the total number of MONW subjects may concern even up to 30%, some efforts were undertaken in order to identify this disease [1].

The first criteria for identification of metabolic syndrome among non-obese people was proposed in 1998 by Rudermann et al. [1]. A system composed of 22 traits was created on the basis of the analysis of earlier research. Each of them was marked with a numerical value (**Table 1**). The Metabolically Obese Normal-Weight (MONW) was supposed to be recognised when the sum of those values reached 7 points. This system seems to be easy to use in everyday practice, although it requires the use of the results of biochemical tests that are rarely conducted among non-obese people [2].

Further criteria of the MONW diagnosis were based on the indices of carbohydrate metabolism disorders and insulin resistance, adipose tissue content in the organism and also with the use of the criteria of metabolic syndrome (**Table 2**).

Table 1. MONW identification criteria according to Ruderman et al. [2]

Examined parameter	Indicated abnormality		Number of points
BMI	25–27 kg/m^2		2
	23–25 kg/m^2		1
Waist circumference	Women	Men	
	> 76.2 cm	> 91.4 cm	2
	71.1–76.2 cm	86.3–91.4 cm	1
Interview concerning the body mass	Weight gain after 18 years of age.	Weight gain after 21 years of age.	
	> 4 kg		1
	> 8 kg		2
	> 12 kg		3
Glucose concentration	IFG		2
	Gestational diabetes		3
	IGT		4
	Type 2 diabetes		4
Triglyceride concentration	100–150 mg/dl		1
	> 150 mg/dl		2
	> 150 mg/dl + HDL < 35 mg/dl		3
Uric acid concentration	> 8 mg/dl		2
Blood pressure	125–140/85–90 mmHg		1
	>140/90 mmHg		2
Medical history	Ischemic heart disease < 60 year of age		3
	Polycystic ovary syndrome		4
Family history	Ischemic heart disease < 60 year of age		2
	High blood pressure < 60 year of age		2
	Hypertriglyceridemia		3
	Type 2 diabetes, IGT		3
Predisposing factors	Low birth weight < 2 kg		2
	Low physical activity < 90 min. of anaerobic exercise/week.		2
High-risk ethnic group			1–3

IFG — impaired fasting glucose; IGT — impaired glucose tolerance; HDL - HDL-cholesterol fraction

Carbohydrate metabolism and insulin resistance

The problem of MONW's characteristics was elaborated by Dvorak's team. He defined MONW on the basis of a BMI below 26.3 kg/m with co-existing insulin resistance (determined by means of the euglycemic clamp technique). The glucose utilisation at a level of 8 mg/min/kg of the Fat Free Mass (FFM) was adopted as the boundary value [3]. A disadvantage of this method is a necessity of carrying out the euglycemic clamp technique examination, which is technically difficult and labour intensive, thereby unsuitable as a tool to be applied in everyday practice [4]. The next attempts aimed at identification of the above-mentioned disorder were undertaken by Molero-Conejo et al. who proposed the recognition of MONW based on body mass index values below 27 kg/m^2, ipso facto, taking into consideration slightly overweight people and a fasting insulin concentration above 84 mmol/l [5]. The MONW diagnosis proposed by Goodpaster et al. was based on the same concept. It adopted BMI values below 25 kg/m^2 and the co-existence of impaired glucose tolerance evaluated by means of an Oral Glucose Tolerance Test (OGTT) and, as a result, making these criteria more realistic to use in everyday practice [6]. An equally simple method was proposed by Canus et al. who recognised MONW on the basis of the same BMI values and the Homeostasis Model Assessment (HOMA) insulin resistance index above 1.69 [7]. It is quite strict criterion because in customary assessment, insulin resistance is recognised only at the value of 2.5. The authors considered though that among people with a normal body mass, we can observe a clinically significant reduction of the tissue's sensitivity to insulin already in the case of much lower values [4]. It is also worth mentioning a proposal of Succurro et al. who, just like his predecessors, assessed the BMI, although they introduced a new index — M_{FFM} — indicating an average glucose infusion rate within the last 60 minutes of the examination

Table 2. MONW recognition criteria according to other authors [4-18, 20, 22-25]

Year	Author	BMI criterion	Other criteria
1999	Dvorak et al.	< 26.3 kg/m^2	Glucose concentration < 8 mg/min/kg FFM in euglycemic clamp
2003	Molero-Conejo et al.	< 27 kg/m^2	Insulin concentration 84 mmol/l (fasting)
2003	Goodpaster et al.	< 25 kg/m^2	Incorrect OGTT
2003/2004	Katsuki et al.	< 25 kg/m^2	Fat tissue in CT > 100 cm^2
2004	Conus et al.	< 25 kg/m^2	HOMA > 1.69
2004	St. Onge et al.	< 27 kg/m^2	Metabolic syndrome criteria according to the NCEP/ATP III
2006	De Lorenzo et al.	< 25 kg/m^2	Percentage of fat tissue > 30%
2008	Wildman et al.	< 25 kg/m^2	Two or more of the following abnormalities: 1. High blood pressure ≥ 130/85 mmHg Hypertension in treatment 2. Higher TG concentration: ≥ 1.7 mmol/l 3. Reduced HDL level: M: < 1 mmol/l W: < 1.3 mmol/l treatment of this disorder. 4. Higher glucose concentration: FG ≥ 6.1 mmol/l Therapy with medicines reducing the glucose level in blood. 5. Insulin resistance HOMA > 5.13 6. Generalised inflammation: hsCRP > 0.1 mg/l
2008	Marques-Vidal et al.	< 25 kg/m^2	Percentage of fat tissue < the 95th percentile depending on sex and age or fat mass index ≥ 8.3 kg/m^2 for men, 11.8 kg/m^2 for women
2008	Succurro et al.	< 25 kg/m^2	M_{FFM} < 10.2 mg/min. x kgFFM
2010	Romero-Corral et al.	< 25 kg/m^2	Percentage of fat tissue > 33.3% among women > 23.1% among men
2012	Shea et al.	< 25 kg/m^2	Percentage of fat tissue: ≥ 35% among women ≥ 20.8% among men + Wildman's criteria
2012	Kim et al.	< 25 kg/m^2	Percentage of fat tissue ≥ 30% among women ≥ 20% among men
2012	Choi et al.	< 25 kg/m^2	Metabolic syndrome criteria according the IDF
2013	Madeira et al.	< 25 kg/m^2	Sum of values of measurement of fold above the scapula and triceps muscle > the 90th percentile for a given sex or a percentage of fat tissue: > 30% among women > 23% among men
2015	Kim et al.	< 25 kg/m^2	Ferritin level > 127.03 ng/ml for women > 46.87 ng/ml for men
2015	Lee et al.	< 25 kg/m^2	TyG value > 8.73 for women > 8.82 for men
2016	Galić et al.	< 25 kg/m^2	Metabolic syndrome criteria according the IDF

by the euglycemic clamp technique expressed in mg/min x kg FFM [8].

Fat mass content

Other diagnostic criteria were proposed by Katsuki et al. who initiated a view on the non-obese patients through the Fat Mass (FM) content in the organism. As their predecessors did, they adopted a BMI below 25 kg/m^2 as the indicative parameters, but they took into consideration the abdominal FM determined by means of computed tomography. The deposit of abdominal FM above 100 cm^2 was adopted as the boundary value [9–11]. However, the execution of computed tomography entails high costs and the exposure

of the patient to ionizing radiation, which excludes this method from use in everyday practice. In turn, de Lorenzo et al. assumed that in order to recognise the Normal Weight Obese (NWO), it is necessary to determine the BMI value within the limits of 18–25 kg/m^2 and the FM content in the organism over 30% determined by means of dual energy x-ray absorptiometry (DXA). Admittedly, it is a safer and cheaper method, but it is still insufficiently available to be used on a daily basis [12]. The same methods were used by next researchers, adopting however different cut-off points. Romero-Corral et al. considered the FM level above 33.3% for women and 23.1% for men as increasing the risk of cardiovascular diseases [13]. Similarly, Shea et al. adopted the values of 35% FM for women and 20.8% FM for men as boundary values. They introduced though an additional criterion consistent with the Wildman's diagnostic criteria presented below [14, 15]. Kim et al. also considered 30% FM value for women and 20% FM value for men as decisive, initiating the use of the measurement of FM content in the organism by the method of bioimpedance, which is a far more available and cheaper technique as compared to the DXA [16]. Marques-Vidal et al., while assessing the frequency of NWO occurrence in a population of the Swiss, were guided by the FM content over the 95th percentile or the value of the Fat Mass index (%FM and BMI ratio) ≥ 8.3 kg/m^2 for men and 11.8 kg/m^2 for women [17]. Madeira et al. were assessing the thickness of a fold above the scapula and triceps muscle, recognising those people among whom the sum of these values was above the 90th percentile as the NWO persons. Alternatively, they were assessing the percentage of FM in the organism, applying the limit of 30% for women and 23% for men [18].

Metabolic syndrome criteria

Metabolic syndrome criteria were used for the first time in the MONW diagnosis by St. Onge et al. who proposed an assessment of people with a BMI below 27 kg/m^2 according to the criteria of the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III), which assumes the co-existence of at least three of five of the following disorders:

- waist circumference above 102 cm among men and 88 cm among women;
- triglycerides concentration in serum over 1.7 mmol/l;
- concentration of HDL fraction cholesterol below 1.3 mmol/l among men and below 1.03 mmol/l among women;
- blood pressure over 130/85 mmHg;
- fasting glucose concentration over 6.1 mmol/l [19, 20].

In turn, in order to identify the MONW people, Wildman et al. used the criterion of a BMI below 25 kg/m^2, considering the co-existence of two or more metabolic abnormalities from their own list as the occurrence of metabolism disorders:

- higher level of blood pressure;
- lipid profile disorders, including a higher triglycerides level and reduced HDL cholesterol level;
- higher fasting glucose concentration;
- insulin resistance (HOMA > 5.13);
- generalised inflammation (hsCRP (high- sensitivity C Reactive Protein) > 0.1 mg/l);
- or treatment of the above-mentioned disorders [15].

A Korean researcher Choi et al. also used the BMI below 25 kg/m^2 in the diagnosis of MONW, and they used criteria of the recognition of metabolic syndrome proposed by the International Diabetes Federation (IDF), considering the co-existence of three or more of the following issues as an abnormality:

- waist circumference ≥ 90 cm among men and ≥ 80 cm among women (for the Korean population);
- blood pressure ≥ 130/85 or recognised hypertension;
- hypertriglyceridemia ≥ 1.7 mmol/l;
- reduced HDL cholesterol level among women < 1.3 mmol/l, among men < 1.0 mmol/l or treatment in order to increase its level;
- fasting hyperglycemia ≥ 6.1 mmol/l or recognised type 2 diabetes [21, 21].

Identical criteria were adopted in this year's research by Galić et al. [23].

Other parameters

In the literature in the area of the diagnosis of metabolic syndrome with normal body weight, we can also find proposals of the use of other indexes – including biochemical. Among others, an additional correlation between the occurrence of MONW and ferritin concentration in blood serum

over 127.03 ng/ml for women and 46.87 ng/ml for men was stated [24]. A positive correlation is observed also with the TyG index value (concentration of triglycerides x fasting glucose/2) over 8.73 for women and 8.82 for men [25]. These parameters may be used to an early MONW recognition in the future.

Conclusions

It results from the short overview concerning the criteria of the diagnosis of MONW that the constant diagnostic element adopted by all the authors is the Body Mass Index (BMI). However, there is no common agreement on the boundary value for increased body mass (range from 23 to 27 kg/m^2). In terms of assessment of metabolism disorders, the majority of researchers draw attention to carbohydrate metabolism or insulin resistance recognised on the basis of various criteria. The others considered the content and distribution of fat tissue in the body as the basis for the MONW recognition [9–18]. The researchers centred around Rudermann consider metabolism disorders, i.e. higher triglyceride content, reduced HDL cholesterol level, higher blood pressure [2, 15, 20, 22, 23] and generalised inflammation [15] as crucial. It is worth noting that the first criteria (**Table 1**) also took into consideration a higher uric acid concentration, body mass gain as an adult, predisposing medical history and family factors, while the most recent studies suggest a correlation between the occurrence of MONW and the ferritin level and TyG index [24, 25].

To sum up, despite a great deal of research conducted so far, it seems necessary to set up a group of experts in order to prepare uniform guidelines that will be applicable in everyday clinical practice.

Acknowledgements

Conflict of interest statement
The authors declare no conflict of interest.

Funding sources
There are no sources of funding to declare.

References

1. Tomiyama AJ, Hunger JM, Nguyen-Cuu J, Wells C. Misclassification of cardiometabolic health when using body mass index categories in NHANES 2005–2012. Int J Obes (Lond). 2016 May;40(5):883–886.
2. Ruderman NB, Chrisholm D, Pi-Syner X, Schneider S. The metabolic obese, normal weight individual- revisited. Diabetes. 1998 May;47(5):699–713.
3. Dvorak RV, De Nino WF, Adas PA, Poehlman ET. Phenotipic charakteristic associated with insulin resistance in metabolically obese but normal weight young women. Diabetes. 1999 Nov;48(11):2210–2214.
4. Bucyk B, Tupikowska M, Bednarek-Tupikowska G. Kryteria rozpoznania zespołu metabolicznego z prawidłową masa ciała (MONW). Endokrynol Otyłość. 2009 Dec;5(4):226–232.
5. Molero-Conejo E, Morales LM, Fernandez V, Raleigh X, Gómez ME, Semprún-Fereira M, et. al. Lean adolescents with increased risk for metabolic syndrome. Arch Latinoam Nutr. 2003 Mar;53(1):39–46.
6. Goodpaster BH, Krishnaswami S, Resnick H, Kelley DE, Haggerty C, Harris TB, et. al. Association between region al adipose tissue distribution and both type 2 diabetes and impaired glucose tolerance in elderly man and women. Diabetes Care. 2003 Feb;26(2):372–379.
7. Conus F, Allison DB, Raabasa-Lhoret R, St-Onge M, St-Pierre DH, Tremblay-Lebeau A, et. al. Metabolic and behavioral charactreristics od metabolically obese but normal-weight women. J Clin Endocrinol Metab. 2004 Oct;89(10):5013–5020.
8. Succurro, Marini MA, Frontoni S, Hribal ML, Andreozzi F, Lauro R, et.al. Insulin Secretion in Metabolically Obese, but Normal Weight, and Metabolically Healthy but Obese Individuals. Obesity. 2008 Aug;16(8):1881–1886.
9. Katsuki A, Sumida Y, Urakawa H, Gabazza EC, Murashima S, Maruyama N, et. al. Increased visceral fat and serum levels of triglyceride are associated with insulin resistance in Japanese metabolically obese, normal-weight subjects with normal glucose tolerance. Diabetes Care. 2003 Aug;26(8):2341–4234.
10. Katsuki A, Sumida Y, Urakawa H, Gabazza EC, Murashima S, Matsumoto K, et. al. Plasma levels of adiponectin are associated with insulin resistance and serum levels of triglyceride in Japanese metabolically obese, normal-weight man with normal glucose tolerance. Diabetes Care. 2003 Oct;26(10):2964–2965.
11. Katsuki A, Sumida Y, Urakawa H, Gabazza EC, Murashima S, Nakatani K, et.al. Increased oxidative stress is associated with serum levels od triglyceride, insulin resistance and hiperinsulinemia in Japanese metabolically obese, normal-weight man. Diabetes Care. 2004 Feb;27(2):631–632.
12. De Lorenzo A, Nartinoli R, Vaia F, Di Renzo L. Normal weight obese (NWO) women: an evaluation of candidate new syndrome. Nutr Metab Cardiovasc Dis. 2006 Dec;16(8):513–523.
13. Romero-Corral A, Somers VK, Sierra-Johnson J, Korenfeld Y, Boarin S, Korinek J, et.al. Normal weight obesity: a risk factor for cardiometabolic disregulation and cardiovascular mortality. Eur Heart J. 2010 Mar;31(6):737–746.
14. She JL, King MTC., Yi Y, Gulliver W, Sun G. Body fat percentage is associated with cardiometabolic dysregulation in BMI-defined normal weight subjects. Nutr Metabol Cardiovasc Dis. 2012 Sep;22(9):741–747.
15. Wildman RP, Muntner P, Reynolds K, McGinn AP, Rajpathak S, Wylie-Rosett J, et. al. The Obese

Without Cardiometabolic Risk Factor Clustering and the Normal Weight With Cardiometabolic Risk Factor ClusteringPrevalence and Correlates of 2 Phenotypes Among the US Population (NHANES 1999–2004). Arch Inter Med. 2008 Aug 11;168(15):1617–1624.
16. Kim JY, Han SH., Yang BM.: Implication of High-Body-Fat Percentage on Cardiometabolic Risk in Middle-Aged Healthy, Normal-Weight Adults. Obesity. 2013 Aug;21(8):1571–1577.
17. Marques-Vidal P, Pécoudo A, Hayoz D, Paccaud F, Mooser V, Waeber G, et. al. Prevelence of normal Wight obesity in Switzerland: effect of various definitions. Eur J Nutr. 2008 Aug;47(5):251–257.
18. Madeira FB, Silva AA, Veloso HF, Goldani MZ, Kac G, Cardoso VC, et. al. Normal Weight Obesity Is Associated with Metabolic Syndrome and Insulin Resistance in Young Adults from a Middle-Income Country. Plos One. 2013;8(3):e60673. doi: 10.1371/journal.pone.0060673. Epub 2013 Mar 28.
19. NCEP/ATP III. 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 17;106(25):3143–3421.
20. St. Onge MP, Janssen I, Heynsfield SB. Metabolic syndrome in normal weight Americans. New definitions of metabolically obese, normal weight individuals. Diabetes Care. 2004 Sep;27(9):2222–2228.
21. Alberti K, Eckel, Groundy S, Zimmet PZ, Cleeman JI, Donato KA, et. al. Harmonizng the Metabolic Syndrome. A Joint Interim Statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung and Blood Institiute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association of the Study of Obesity. Circulation. 2009 Oct 20;120(16):1640–1645.
22. Choi J, Se-Young O, Lee D, Tak S, Hong M, Park SM, et. al Characteristics of diet patterns in metabolically obese, normal weight adults (Korean national Health and Nutrition Examination III, 2005). Nutr Metab Cardiovasc Dis. 2012 Jul;22(7):567–574.
23. Galić BS, Pavlica T, Udicki M, Stokić E, Mikalački M, Korovljev D, et. al. Somatotype characteristics of normal-weight and obese women among different metabolic subtype. Arch Endocrinol Metab. 2016 Feb;60(1):60–65.
24. Kim JW, Kim DH, Roh YK, Ju SY, Nam HY, Nam GE, et. al. Serum Ferritin Levels Are Positively Associated With Metabolicall Obese Normal Weight A Nationwide Population-Based Study. 2015 Dec;94(52):e2335. doi: 10.1097/MD.0000000000002335.
25. Lee SH, Han K, Yang HK, Kim HS, Cho JH, Kwon HS, et. al. A novel criterion for identyfying metabolically obese but normal weight individuals using the product of triglicerides and glucose. Nutr Diabetes. 2015 Apr 27;5:e149. doi: 10.1038/nutd.2014.46.

Acceptance for editing: 2018-03-12
Acceptance for publication: 2018-03-27

Correspondence address:
Juliusz Przysławski
Chair and Department of Bromatology and Human Nutrition, Poznan University of Medical Sciences
42 Marcelinska Street, 60-354 Poznan, Poland
phone: +48618547197
fax: +48618547198
email: jotespe@ump.edu.pl