ПАТОЛОГИЧЕСКАЯ ФИЗИОЛОГИЯ

УДК 159.922:616-008.9-053.8-055:616.4
DOI: 10.34680/2076-8052.2023.4(133).565-575
ГРНТИ 15.21.59+76.29.37+76.29.33
Специальность ВАК 3.3.3

Research Article

GENDER FEATURES OF METABOLIC SYNDROME COMPONENTS IN YOUNG AGE

Sumerkina V. A.[1], Chulkov V. S.[2], Golovneva E. S.[1, 3], Telesheva L. F.[1]

[1]South Ural State Medical University (Chelyabinsk, Russia);
[2]Yaroslav-the-Wise Novgorod State University (Veliky Novgorod, Russia)
[3] Multidisciplinary Center of Laser Medicine (Chelyabinsk, Russia)

Abstract The article analyzes the clinical and laboratory features of young men and women with abdominal obesity and metabolic syndrome. The study was carried out on 173 patients of both sexes aged 18-45 years. The patients were divided into 3 groups: group 1 – isolated abdominal obesity (AO); group 2 – combination of abdominal obesity with 1 of the metabolic syndrome components (AO+1); group 3 – metabolic syndrome (MetS). It was found that in young men, the values of carbohydrate (glucose, insulin) and lipid metabolism (HDL cholesterol, LDL cholesterol, triglycerides), insulin resistance indices (HOMA-IR, TyG) in the AO and AO+1 groups were homogeneous. However, the ratio of TG/HDL in the AO+1 group exceeded the value of the AO group. Women in the AO+1 group showed changes relative to the group of women with isolated AO that are hyperglycemia, increased LDL cholesterol, insulin resistance (increased TG/HDL) and dysfunction of visceral adipose tissue (increased VAI). Young men with MetS are characterized by excess body weight, hyperglycemia, dyslipidemia (increased LDL cholesterol and triglycerides), insulin resistance (as measured by TyG and TG/HDL), and dysfunction of visceral adipose tissue. The gender feature of women is the development of MetS on the background of obesity, dysfunction of visceral adipose tissue and insulin resistance in combination with deeper changes in lipid metabolism (increased LDL cholesterol and triglycerides, as well as a decrease in HDL cholesterol).

Keywords: abdominal obesity, metabolic syndrome, gender characteristics

For citation: Sumerkina V. A., Chulkov V. S., Golovneva E. S., Telesheva L. F. Gender features of metabolic syndrome components in young age // Vestnik NovSU. 2023. 4(133). 565-575. DOI: 10.34680/2076-8052.2023.4(133).565-575

Научная статья

ГЕНДЕРНЫЕ ОСОБЕННОСТИ КОМПОНЕНТОВ МЕТАБОЛИЧЕСКОГО СИНДРОМА У ЛИЦ МОЛОДОГО ВОЗРАСТА

Сумеркина В. А.[1], Чулков В. С.[2], Головнева Е. С.[1, 3], Телешева Л. Ф.[1]

[1]Южно-Уральский государственный медицинский университет (Челябинск, Россия);
[2]Новгородский государственный университет имени Ярослава Мудрого (Великий Новгород, Россия)
[3]Многопрофильный центр лазерной медицины (Челябинск, Россия)

Аннотация В работе выполнен анализ клинико-лабораторных особенностей мужчин и женщин молодого возраста с абдоминальным ожирениеми метаболическим синдромом. Исследование выполнено на 173 пациентах обоего пола 18-45 лет. Пациенты распределены в 3 группы: группа 1 – изолированное абдоминальное ожирение (АО); группа 2 – сочетание абдоминального ожирения с 1 из компонентов метаболического синдрома (АО+1); группа 3 – метаболический синдром (МС).

Установлено, что у мужчин молодого возраста значения показателей углеводного (глюкоза, инсулин) и липидного обмена (Хс-ЛПВП, Хс-ЛПНП, триглицериды), индексы инсулинорезистентности (HOMA-IR, TyG) в группах АО и АО+1 были однородны, однако соотношение Тг/ЛПВП в группе АО+1 превышало значение группы АО. У женщин в группе АО+1 выявлены изменения относительно группы женщин с изолированным АО – гипергликемия, повышение Хс-ЛПНП, инсулинорезистентность (повышение Тг/ЛПВП) и дисфункция висцеральной жировой ткани (повышение VAI). Для мужчин молодого возраста с МС характерен избыток массы тела, гипергликемия, дислипидемия (повышение Хс-ЛПНП и триглицеридов), инсулинорезистентность (по результатам TyGиТг/ЛПВП) и дисфункция висцеральной жировой ткани. Гендерной особенностью женщин является развитие МС на фоне ожирения, дисфункции висцеральной жировой ткани и инсулинорезистентности в сочетании с более глубокими изменениями липидного обмена (повышение Хс-ЛПНП и триглицеридов, а также снижение Хс-ЛПВП).

Ключевые слова: абдоминальное ожирение, метаболический синдром, гендерные особенности

Для цитирования: Сумеркина В. А., Чулков В. С., Головнева Е. С., Телешева Л. Ф. Гендерные особенности компонентов метаболического синдрома у лиц молодого возраста // Вестник НовГУ. 2023. 4(133). 565-575. DOI: 10.34680/2076-8052.2023.4(133).565-575

Introduction

Metabolic syndrome (MetS) is one of the current clinical problems. There have been no large-scale epidemiological studies on the prevalence of MetS in the world, but according to various authors, depending on the region of residence, the composition of the population studied and the diagnostic criteria used, the frequency of MetS in the general population is 20-30% [1]. MetS is detected 3 times more often than type 2 diabetes mellitus [2], and a steady increase in its growth rate is predicted.

According to WHO, about 30% of the world's population are overweight, every twentieth person has a carbohydrate metabolism disorder; the number of patients progressively increases every 10 years by 10%. The prevalence of obesity is growing catastrophically in all industrialized countries [3]. In 2013, 24.1% of the population of our country were obese, and according to this indicator, the Russian Federation is in 8th place in the world [4]. Visceral obesity with predominant fat deposition in the abdominal area is particularly dangerous.

Despite the close relationship between MetS and overweight (or obesity), it is necessary to emphasize that visceral (abdominal) obesity is a significant pathogenic factor, which in routine clinical practice is determined by an increase in the volume of adipose tissue in the abdominal region. At the same time, an important aspect of recent research is the recognition of the so-called “metabolically healthy obesity,” in which excess subcutaneous adipose tissue is not accompanied by metabolic disorders [5].

It must be emphasized that the majority of patients with MetS are of working age; an increase in the prevalence of MetS among young people has been recorded [6]. Currently, progress has been made in understanding the mechanisms of development of individual components of MetS, but the etiology and pathogenesis of MetS have not been fully studied. Thus, the pathogenetic patterns of the emergence and development of temporary connections between abdominal obesity (AO) and other components of MetS have not yet been revealed. There are controversial issues about the cause-and-effect relationships of

the various components of MetS and their pathophysiological integration. In addition, there is no understanding of the mechanisms of initiation and progression of typical pathological processes underlying the development of arterial hypertension (AH), dyslipidemia and insulin resistance. At the same time, a clear understanding of the stages of MetS formation will make it possible to determine the individual risk of MetS in patients with AO.

Purpose of the study: to determine the clinical characteristics of young patients with AO and MetS, taking into account gender differences.

Materials and methods

The study was carried out on 173 patients of both sexes, 18-45 years old, with AO (waist circumference >94 cm in men and >80 cm in women), who had an outpatient appointment with a general practitioner or cardiologist at the City Clinical Hospital No. 11 in Chelyabinsk in 2013–2017. AH, AO and MetS were diagnosed according to the recommendations of the Russian Medical Society for Arterial Hypertension, 2020 [7]. Patients underwent anthropometric measurements (waist circumference, height, weight), and body mass indices (BMIs) were calculated. Laboratory testing included determination of the concentration of glucose, insulin, lipid metabolism parameters (low-density lipoprotein cholesterol – LDL-C; high-density lipoprotein cholesterol – HDL-C; triglycerides) in fasting blood serum samples. Laboratory studies were performed on an automatic biochemical analyzer Sapphire-400 (Hirose Electronic System, Japan) and an automatic biochemical and enzyme-immunoassay analyzer AnaletteBiochem (HTI, USA). Insulin resistance indices HOMA-IR, TG/HDL-C, TyG were calculated; visceral adipose tissue dysfunction index (VAI):

HOMA-IR = Glucose (mmol/l) * Insulin (μIU/ml) / 22,5;

TyG = Ln [Triglycerides (mg/dL) × Glucose (mg/dL) / 2];

VAI in men = (WC/(39,68 + (1,88 × BMI)) × TG/1,03 × 1,31/HDL-C;

VAI in women = (WC/(36,58 + (1,89 × BMI)) × TG/0,81 × 1,52/HDL-C.

Statistical processing of the obtained results was performed using the STATISTICA 10 software system (StatSoft, Inc., 2011, USA). The data was processed using descriptive statistics methods. To determine the differences between compared independent samples, the nonparametric Kruskal-Wallis test was used; post-hoc comparison of groups was performed using the Mann-Whitney test. For all analyses, $p<0.05$ was considered the critical level of significance.

Findings and discussion

The distribution of the cardiometabolic risk factors described above that meet the criteria for MetS among young patients with AO is presented in table 1.

The body mass index (BMI) value in patients with AO corresponded to overweight, however, among women, 47% were diagnosed with obesity, and 19% of women with AO had a normal body mass index. Among the components of MetS, the most common was

an increase in LDL-C (51% of patients with AO), while hyperglycemia was determined only in 9% of cases.

Table 1. Clinical characteristics of patients with abdominal obesity, Me ($Q_{25\%}$ - $Q_{75\%}$)

Indicator	Total (n=173)	Men (n=93)	Women (n=80)
Waist circumference (WC), cm	98 (92-104)	101 (97-106)	91 (86-96)
Body mass index (BMI), kg/m^2	28.7 (26.3-32.0)	28.4 (26.5-30.7)	25.7 (24.2-27.3)
Normal body weight abs. (%)	19 (11%)	4 (4%)	15 (19%)
Excess body weight abs. (%)	88 (51%)	61 (66%)	27 (34%)
Obesity, abs. (%)	66 (38%)	28 (30%)	38 (47%)
Metabolic syndrome, abs. (%)	78 (45%)	47 (51%)	31 (39%)
Arterial hypertension, abs. (%)	67 (39%)	38 (41%)	29 (36%)
Triglycerides >1.7 mmol/l, abs. (%)	49 (28%)	34 (37%)	15 (19%)
HDL-C <1.0 mmol/l in men; <1.2 mmol/l in women, abs. (%)	44 (25%)	24 (26%)	20 (25%)
LDL-C >3.0 mmol/l, abs. (%)	89 (51%)	48 (52%)	41 (51%)
Glucose > 6.1 mmol/l, abs. (%)	16 (9%)	7 (8%)	9 (11%)
Glucose, mmol/l	5.4 (5.0-5.8)	5.4 (5.0-5.8)	5.3 (5.0-5.8)
HDL-C, mmol/l	1.4 (1.0-1.8)	1.2 (0.9-1.7)	1.5 (1.2-1.9)
LDL-C, mmol/l	3.1 (2.4-3.9)	3.1 (2.4-3.8)	3.3 (2.4-3.9)
Triglycerides, mmol/l	1.1 (0.8-1.9)	1.2 (0.8-2.1)	1.0 (0.7-1.6)

When analyzing the clinical and laboratory data of patients in the study cohort, it was found that in 32 cases (18%) AO was not combined with MetS components (isolated AO, group 1, AO); in 63 patients (37%) with AO, 1 of MetS components was identified (group 2, AO+1) and in 78 patients (45%) with AO, MetS was diagnosed (group 3, MetS) (Table 2).

As a result of the analysis of anthropometric indicators of patients in the above groups, it was found that the WC value in the AO+1 group exceeded the value in the AO group, and in MetS it was greater compared to all other groups. BMI increased as MetS components were added. Its median values in the AO and AO+1 groups corresponded to overweight, and in patients with MetS — to obesity of the 1st degree. More than half of patients with MetS were obese. In patients of the AO+1 group, abdominal obesity was most often combined with an increase in LDL-C (41%) and AH (30%). Among patients with MetS, the most common components were increased LDL-C (82%), AH (59%) and

increased triglycerides (55%). In patients with MetS, abdominal obesity was combined with 2 additional components in 45 people (58%), with 3 or more in 33 cases (42%). The median glucose level in patients in the AO+1 and MetS groups did not exceed the threshold value for metabolic syndrome of 6.1 mmol/l, however, in the AO+1 group it was higher than in AO, and in the MetS group it was higher relative to all other groups. Changes in lipid metabolism were characterized by a decrease in HDL-C in patients of the AO+1 and MetS groups relative to the AO group. An increase in LDL-C levels was detected in the AO+1 group. In patients with MetS, the concentration of LDL-C and triglycerides was higher than in all other study groups.

It is known that an increase in the volume of visceral elastic tissue does not always lead to metabolic disorders. In this regard, the Visceral Adiposity Index (VAI), which monitors waist circumference, body mass index, glucose and triglyceride density, is used as a marker of dysfunction and distribution of adipose tissue. Analysis of our results showed that the HOMA-IR index was homogeneous in all groups of patients. The TG/HDL-C ratio, as well as VAI in the AO+1 and MetS groups was higher than in isolated AO, and in patients with MetS the value in the AO+1 group was 2 times higher. The TyG index in patients with MetS was higher than in all other study groups.

Table 2. Clinical characteristics of patients of both sexes in the comparison groups, Me ($Q_{25\%}$ - $Q_{75\%}$)

Indicator	AO (group 1; n=32)	AO+1 (group 2; n=63)	MetS (group 3; n=78)	p
Waist circumference (WC), cm	91 (86-96)	98 (89-102)	102 (97-108)	P_{1-2}=0.003 P_{1-3}<0.001 P_{2-3}<0.001
Body mass index (BMI), kg/m^2	25.7 (24.2-27.3)	28.4 (26.2-30.5)	30.8 (28.6-34.2)	P_{1-2}<0.001 P_{1-3}<0.001 P_{2-3}<0.001
Normal body weight abs. (%)	9 (28%)	7 (11%)	3 (4%)	P_{1-2}=0.036 P_{1-3}<0.001
Excess body weight abs. (%)	21 (66%)	37 (59%)	30 (39%)	P_{1-3}=0.01 P_{2-3}=0.02
Obesity, abs. (%)	2 (6%)	19 (30%)	45 (58%)	P_{1-3}<0.001 P_{2-3}=0.001
Arterial hypertension, abs. (%)	-	19 (30%)	48 (62%)	P_{2-3}<0.001
Triglycerides >1.7 mmol/l, abs. (%)	-	6 (10%)	43 (55%)	P_{2-3}<0.001
HDL-C <1.0 mmol/l in men; <1.2 mmol/l in women, abs. (%)	-	11 (18%)	33 (42%)	P_{2-3}=0.002
LDL-C >3.0 mmol/l, abs. (%)	-	26 (41%)	64 (82%)	P_{2-3}<0.001
Glucose > 6.1 mmol/l, abs. (%)	-	1 (2%)	15 (19%)	P_{2-3}=0.002
Glucose, mmol/l	5.0 (4.8-5.4)	5.3 (4.9-5.6)	5.7 (5.3-6.0)	P_{1-2}=0.026 P_{1-3}<0.001 P_{2-3}<0.001

Insulin, μIU/ml	9.8 (7.0-44.7)	12.4 (7.9-22.5)	15.5 (10.0-26.1)	n/s
HDL-C, mmol/l	1.7 (1.3-2.4)	1.4 (1.1-1.8)	1.2 (0.9-1.6)	P_{1-3}<0.008
LDL-C, mmol/l	2.5 (2.2-2.7)	2.8 (2.2-3.6)	3.8 (3.2-4.3)	P_{1-2}=0.018 P_{1-3}<0.001 P_{2-3}<0.001
Triglycerides, mmol/l	0.8 (0.6-1.0)	0.8 (0.7-1.3)	1.8 (1.2-2.6)	P_{1-3}<0.001 P_{2-3}<0.001
HOMA-IR	2.2 (1.6-11.5)	3.0 (1.8-5.4)	4.3 (2.4-7.1)	n/s
TG/HDL-C	0.41 (0.29-0.65)	0.68 (0.46-0.89)	1.38 (1.00-2.09)	P_{1-2}=0.001 P_{1-3}<0.001 P_{2-3}<0.001
TyG	4.35 (4.26-4.49)	4.45 (4.31-4.65)	4.85 (4.61-5.02)	P_{1-3}<0.001 P_{2-3}<0.001
VAI	0.77 (0.55-1.11)	1.11 (0.76-1.60)	2.33 (1.45-3.49)	P_{1-2}=0.002 P_{1-3}<0.001 P_{2-3}<0.001

Note: n/s — differences are statistically non-significant (p>0.05).

In accordance with the purpose of the study, the characteristics described above were analyzed in men and women.

In men, the study of anthropometric indicators in the AO, AO+1 and MetS groups indicated an increase in abdominal obesity and excess body weight (Table 3). However, the median BMI values in the AO and AO+1 groups did not differ and corresponded to excess body weight. In men with MetS, higher values of glucose, LDL-C and triglycerides were determined compared to patients of other groups. When analyzing the frequency of detection of MetS components in men, the same patterns were established as in the group of patients of both sexes, however, the proportion of people with reduced HDL-C levels in the AO+1 and MetS groups did not have statistically significant differences. It was found that the TG/HDL-C ratio, as well as VAI in the AO+1 and MetS groups is higher than in isolated AO, and in patients with MetS it is 2 times higher than the value in the AO+1 group. The TyG index in men with MetS was higher than in all other study groups.

Table 3. Clinical characteristics of men with AO, AO+1 and MetS, Me (Q25% - Q75%)

Indicator	AO (group 1; n=13)	AO+1 (group 2; n=33)	MC (group 3; n=47)	p
Waist circumference (WC), cm	96 (95-100)	100 (98-103)	102 (98-108)	P_{1-2}=0.026 P_{1-3}=0.002
Body mass index (BMI), kg/m^2	26.3 (18.7-29.1)	27.2 (25.6-29.1)	29.6 (28.4-31.6)	P_{1-3}<0.001 P_{2-3}<0.001
Normal body weight abs. (%)	1 (8%)	3 (9%)	-	P_{2-3}=0.036
Excess body weight abs. (%)	12 (92%)	24 (73%)	25 (53%)	P_{1-3}=0.011
Obesity, abs. (%)	-	6 (18%)	22 (47%)	P_{1-3}=0.002 P_{2-3}=0.007
Arterial hypertension, abs. (%)	-	10 (33%)	19 (61%)	P_{2-3}=0.05

Triglycerides >1.7 mmol/l, abs. (%)	-	-	15 (48%)	P_{2-3}<0.001
HDL-C <1.0 mmol/l, abs. (%)	-	4 (13%)	16 (52%)	P_{2-3}<0.001
LDL-C >3.0 mmol/l, abs. (%)	-	15 (50%)	26 (84%)	P_{2-3}<0.005
Glucose > 6.1 mmol/l, abs. (%)	-	1 (3%)	8 (26%)	P_{2-3}=0.011
Glucose, mmol/l	5.1 (5.0-5.5)	5.2 (4.9-5.4)	5.6 (5.2-5.9)	P_{1-3}=0.008 P_{2-3}=0.002
Insulin, μIU/ml	10.3 (7.8-15.0)	13.0 (7.9-21.8)	18.4 (10.3-37.5)	n/s
HDL-C, mmol/l	1.3 (1.1-1.5)	1.2 (1.0-1.8)	1.2 (0.9-1.6)	n/s
LDL-C, mmol/l	2.5 (2.3-2.7)	2.7 (2.0-3.3)	3.7 (3.1-4.0)	P_{1-3}<0.001 P_{2-3}<0.001
Triglycerides, mmol/l	0.9 (0.6-1.0)	0.8 (0.7-1.5)	2.0 (1.2-2.7)	P_{1-3}<0.001 P_{2-3}<0.001
HOMA-IR	2.4 (1.9-3.4)	2.9 (1.8-4.7)	4.7 (2.3-8.7)	n/s
TG/HDL-C	0.55 (0.36-0.80)	0.83 (0.53-1.15)	1.43 (1.00-2.33)	P_{1-2}=0.037 P_{1-3}<0.001 P_{2-3}<0.001
TyG	4.44 (4.28-4.49)	4.42 (4.34-4.75)	4.86 (4.64-5.03)	P_{1-3}<0.001 P_{2-3}<0.001
VAI	0.79 (0.50-1.04)	1.16 (0.73-1.60)	1.92 (1.33-3.29)	P_{1-3}<0.001 P_{2-3}<0.001

Note: n/s — differences are statistically non-significant (p>0.05).

The body mass index in women in the AO and AO+1 groups corresponded to overweight, while in MetS it corresponded to obesity of the 1st degree (Table 4). In women with MetS, obesity was diagnosed in 74% of cases, which corresponds to the data of other authors [8]. Among patients with MetS, the most common components were increased LDL-C (84%), AH (61%) and decreased HDL-C (52%). The glucose concentration in women in the AO+1 group was higher than in the AO group, and in the MetS group it was higher relative to all other groups. Dyslipidemia in women was characterized by a decrease in HDL-C in the AO+1 and MetS groups relative to the AO group. A higher LDL-C content was revealed in the AO+1 group relative to the AO group. In women with MetS, the concentration of LDL-C and triglycerides was higher than in all other study groups. Changes in insulin resistance in women in the AO+1 and MetS groups were characterized by an increase in the TG/HDL-C index relative to the AO group; in women with MetS this indicator was 2.5 times higher than in women in the AO+1 group. The TyG index in women with MetS exceeded the value in all other study groups. The VAI in the AO+1 and MetS groups was higher than in women with AO, and in MetS it was higher than when AO was combined with 1 of its criteria.

Table 4. Clinical characteristics of women with AO, AO+1 and MetS, Me ($Q_{25\%}$ - $Q_{75\%}$)

Indicator	AO (group 1; n=19)	AO+1 (group 2; n=30)	MetS (group 3; n=31)	p
Waist circumference (WC), cm	87 (84-90)	89 (86-96)	100 (92-106)	P_{1-2}=0.048 P_{1-3}<0.001 P_{2-3}<0.001
Body mass index (BMI), kg/m^2	25.6 (23.2-27.2)	29.2 (27.2-32.7)	33.2 (30.5-38.2)	P_{1-2}=0.002 P_{1-3}<0.001 P_{2-3}=0.002
Normal body weight abs. (%)	8 (42%)	4 (14%)	3 (10%)	P_{1-2}=0.027 P_{1-3}=0.008
Excess body weight abs. (%)	9 (47%)	13 (43%)	5 (16%)	P_{1-3}=0.018 P_{2-3}=0.021
Obesity, abs. (%)	2 (11%)	13 (43%)	23 (74%)	P_{1-2}=0.018 P_{1-3}<0.001 P_{2-3}=0.014
Arterial hypertension, abs. (%)	-	9 (27%)	29 (62%)	P_{2-3}=0.004
Triglycerides >1,7 mmol/l, abs. (%)	-	6 (18%)	28 (60%)	P_{2-3}<0.001
HDL-C <1,2 mmol/l, abs. (%)	-	7 (21%)	17 (36%)	n/s
LDL-C >3,0 mmol/l, abs. (%)	-	11 (33%)	37 (79%)	P_{2-3}<0.001
Glucose > 6.1 mmol/l, abs. (%)	-	-	7 (15%)	P_{2-3}=0.02
Glucose, mmol/l	4.9 (4.6-5.2)	5.3 (4.9-5.8)	5.8 (5.3-6.1)	P_{1-2}=0.012 P_{1-3}<0.001 P_{2-3}=0.006
Insulin, µIU/ml	7.8 (7.0-56.3)	11.8 (8.6-25.4)	13.6 (9.1-24.6)	n/s
HDL-C, mmol/l	1.9 (1.6-2.5)	1.6 (1.3-1.9)	1.1 (1.0-1.4)	P_{1-3}<0.001 P_{2-3}=0.016
LDL-C, mmol/l	2.5 (2.2-2.8)	3.1 (2.4-3.8)	3.9 (3.4-4.4)	P_{1-2}=0.015 P_{1-3}<0.001 P_{2-3}<0.007
Triglycerides, mmol/l	0.7 (0.6-1.0)	0.8 (0.7-1.2)	1.7 (1.1-2.1)	P_{1-3}<0.001 P_{2-3}<0.001
HOMA-IR	1.7 (1.6-11.7)	3.0 (2.3-5.9)	3.4 (2.4-7.0)	n/s
TG/HDL-C	0.38 (0.28-0.59)	0.54 (0.44-0.85)	1.36 (0.91-2.00)	P_{1-2}=0.015 P_{1-3}<0.001 P_{2-3}<0.001
TyG	4.31 (4.26-4.47)	4.46 (4.30-4.62)	4.82 (4.58-4.97)	P_{1-3}<0.001 P_{2-3}<0.001
VAI	0.77 (0.56-1.12)	0.98 (0.79-1.60)	2.60 (1.76-3.94)	P_{1-2}=0.027 P_{1-3}<0.001 P_{2-3}<0.001

Note: n/s – differences are statistically non-significant (p>0.05).

Thus, in young men and women, isolated AO is recorded against the background of excess body weight.

When AO was combined with one of the MetS criteria, patients were found to have

excess body weight and a more pronounced increase in WC relative to isolated AO. The study of biochemical parameters of carbohydrate and lipid metabolism made it possible to establish an increase in the level of glucose and LDL-C relative to patients in the AO group. It is important to emphasize that the median values of the above indicators in patients of the AO+1 group did not reach the limits established for MetS. We also recorded higher values of indices that indirectly indicate the presence of insulin resistance (TG/HDL-C and TyG). These indicators did not go beyond the cut-off limits (TG/HDL-C>1.32 and TyG>4.49), however, the TG/HDL-C ratio with a combination of AO and 1 MetS criterion was higher relative to patients with AO. The VAI value in patients of the AO+1 group indicated the presence of dysfunction of visceral adipose tissue and was statistically significantly higher than in patients with AO.

In men, the values of carbohydrate and lipid metabolism in the AO and AO+1 groups were homogeneous, the TG/HDL insulin resistance index in the AO+1 group was higher than in the AO group.

In the subgroup of women with a combination of AO and one of the criteria, changes in carbohydrate metabolism were similar to the gender-mixed group. The LDL-C content exceeded the cut-off value (> 3.0 mmol/l) and was higher than in the AO group. The VAI in women of the AO+1 group was within normal limits, but its median value was higher than in the AO group.

In patients with MetS, the body mass index value corresponded to obesity of the 1st degree. Waist circumference, which indirectly reflects excess abdominal fat, was greater in MetS than in the AO and AO+1 groups. Glucose levels were higher relative to all other study groups. Dyslipidemia was characterized by increased levels of LDL-C and triglycerides and a decrease in HDL-C relative to other groups. The concentration of LDL-C and triglycerides was outside the established reference intervals. In this group of patients, laboratory markers indicated the presence of insulin resistance (increased TG/HDL-C and TyG). It is interesting to note that despite the values of these indices exceeding the reference limits, the TG/HDL-C and TyG indicators were statistically significantly higher than in patients of the AO and AO+1 groups, and HOMA-IR was homogeneous in all patients with AO. The VAI in MetS was higher than in other groups, and its value indicated the pathology of visceral adipose tissue. More than half of patients of both sexes with MetS had AH.

In men with MetS, similar changes in indicators were identified as in patients of both sexes, however, the median value of body mass index corresponded to overweight, and waist circumference exceeded the value in patients of the AO group and did not differ from the value of men in the AO+1 group. The HDL-C level did not differ from the AO and AO+1 groups.

For women with MetS, along with the changes in anthropometric and biochemical parameters described above, characteristic differences were also established in

comparison with patients of both sexes. The HDL-C level was lower than in other study groups and was outside the reference interval.

Conclusion

MetS is a proven cardiometabolic risk factor. The occurrence and progression of MetS can be presented in the following sequence: excess visceral adipose tissue or abdominal obesity (AO, stage 1) induces the formation of visceral adipose tissue dysfunction and insulin resistance, the appearance of one of the components of the metabolic syndrome (AO+1, stage 2) with a subsequent increase dysfunction of visceral adipose tissue and insulin resistance, the addition of the second and subsequent components of MetS (MetS, stage 3). The high prevalence of MetS in the population determines the relevance of diverse interdisciplinary studies of AO and MetS in order to develop systematic approaches to its correction, which, in turn, indicates the importance of developing a general pathogenesis scheme taking into account all known components of MetS.

References

1. Pucci G., Alcidi R., Tap L., Battista F., Mattace-Raso F., Schillaci G. Sex- and gender-related prevalence, cardiovascular risk and therapeutic approach in metabolic syndrome: a review of the literature // Pharmacological Research. 2017. 120. 34-42. DOI: 10.1016/j.phrs.2017.03.008

2. Kitikova O. Yu., Antonyuk M. V., Kantur T. A., Novgorodtseva T. P., Denisenko Yu. K. Rasprostranennost' i biomarkery metabolicheskogo sindroma [Prevalence and biomarkers of metabolic syndrome] // Obesity and metabolism. 2021. 18(3). 302-312. DOI: 10.14341/omet12704

3. Obesity and overweight. Geneve. World Health Organization (WHO). 2021. Available at: https://www.who.int/newsroom/fact-sheets/detail/obesity-and-overweight (Accessed: 30.08.2023).

4. Shlyakhto E. V., Nedogoda S. V., Konradi A. O., Baranova E. I., Fomin V. V., Vertkin A. L., Chumakova G. A. Kontseptsiya novykh natsional'nykh klinicheskikh rekomendatsiy po ozhireniy [The concept of new national clinical guidelines on obesity] // Russian Journal of Cardiology. 2016.132(4). 7-13. DOI: 10.15829/1560-4071-2016-4-7-13

5. Ostrovskaya E. V., Romantsova T. I., Gerasimov A. V., Novoselova T. V. Rasprostranennost' metabolicheski zdorovogo ozhireniya po dannym vyborki Moskovskogo regiona [Prevalence of metabolically healthy obesity according to a sample of the Moscow region] // Obesity and metabolism. 2017. 14(4). 51-56. DOI: 10.14341/omet2017451-56

6. Larina N. G., Roitman T. I., Weber V. R., Pogrebnyak L. N., Secheneva L. V., Davydova T. A. Markery metabolicheskogo sindroma u podrostkov s konstitutsional'no-ekzogennym ozhireniyem [Markers of metabolic syndrome in adolescents with constitutionally exogenous obesity] // Vestnik NovSU. 2019. 3(115). 18-20. DOI: 10.34680/2076-8052.2019.3(115).18-20

7. Rekomendatsii po vedeniyu bol'nykh arterial'noy gipertoniyey s metabolicheskimi narusheniyami i sakharnym diabetom 2-go tipa [Recommendations for the management of patients with arterial hypertension with metabolic disorders and type 2 diabetes mellitus] // Systemic hypertension. 2020. 17(1). 7-45. DOI: 10.26442/2075082X.2020.1.200051

8. Regitz-Zagrosek V., Lehmkuhl E., Mahmoodzadeh S. Gender aspects of the role of the metabolic syndrome as a risk factor for cardiovascular disease // Gender Medicine. 2007. 4(Suppl B). S162–S177. DOI: 10.1016/s1550-8579(07)80056-8

Список литературы

1. Pucci G., Alcidi R., Tap L., Battista F., Mattace-Raso F., Schillaci G. Sex- and gender-related prevalence, cardiovascular risk and therapeutic approach in metabolic syndrome: a review of the literature // Pharmacological Research. 2017. 120. 34-42. DOI: 10.1016/j.phrs.2017.03.008

2. Кытикова О. Ю., Антонюк М. В., Кантур Т. А., Новгородцева Т. П., Денисенко Ю. К. Распространенность и биомаркеры метаболического синдрома // Ожирение и метаболизм. 2021. 18(3). 302-312. DOI: 10.14341/omet12704

3. Obesity and overweight Geneve // World Health Organization (WHO). 2021. URL: https://www.who.int/newsroom/fact-sheets/detail/obesity-and-overweight (Дата обращения: 30.08.2023).

4. Шляхто Е. В., Недогода С. В., Конради А. О., Баранова Е. И., Фомин В. В., Верткин А. Л., Чумакова Г. А. Концепция новых национальных клинических рекомендаций по ожирению // Российский кардиологический журнал. 2016. 132(4). 7-13. DOI: 10.15829/1560-4071-2016-4-7-13

5. Островская Е. В., Романцова Т. И., Герасимов А. В., Новоселова Т. В. Распространенность метаболически здорового ожирения по данным выборки Московского региона // Ожирение и метаболизм. 2017. 14(4). 51-56. DOI: 10.14341/omet2017451-56

6. Ларина Н. Г., Ройтман Т. И., Вебер В. Р., Погребняк Л. Н., Сеченева Л. В., Давыдова Т. А. Маркеры метаболического синдрома у подростков с конституционально-экзогенным ожирением // Вестник НовГУ. 2019. 3(115). 18-20. DOI: 10.34680/2076-8052.2019.3(115).18-20

7. Рекомендации по ведению больных артериальной гипертонией с метаболическими нарушениями и сахарным диабетом 2-го типа // Системные гипертензии. 2020. 17(1). 7-45. DOI: 10.26442/2075082X.2020.1.200051

8. Regitz-Zagrosek V., Lehmkuhl E., Mahmoodzadeh S. Gender aspects of the role of the metabolic syndrome as a risk factor for cardiovascular disease // Gender Medicine. 2007. 4(Suppl B). S162-S177. DOI: 10.1016/s1550-8579(07)80056-8

Информация об авторах

Сумеркина Вероника Андреевна – кандидат медицинских наук, ведущий научный сотрудник ЦНИЛ, Южно-Уральский государственный медицинский университет (Челябинск, Россия), ORCID: 0000-0003-4842-0875, veronika.sumerkina@mail.ru

Чулков Василий Сергеевич – доктор медицинских наук, доцент, директор Института медицинского образования, профессор, Новгородский государственный университет имени Ярослава Мудрого (Великий Новгород, Россия), ORCID: 0000-0002-0952-6856, Vasily.Chulkov@novsu.ru

Головнева Елена Станиславовна – доктор медицинских наук, профессор, профессор, Южно-Уральский государственный медицинский университет (Челябинск, Россия); заместитель директора по научно-исследовательской работе, Многопрофильный центр лазерной медицины (Челябинск, Россия), ORCID: 0000-0002-6343-7563, main@cgilh.chel.su

Телешева Лариса Федоровна – доктор медицинских наук, профессор, профессор, Южно-Уральский государственный медицинский университет (Челябинск, Россия), ORCID: 0000-0002-7884-9675, teleshevalarisa@mail.ru