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Prevalence of metabolic syndrome in a Russian population: The Ural Eye and Medical Study and the Ural Very Old Study

Mukharram M. Bikbov [a,**], Gyulli M. Kazakbaeva [a], Timur R. Gilmanshin [a], Rinat M. Zainullin [a], Ellina M. Iakupova [a], Albina A. Fakhretdinova [a], Azaliia M. Tuliakova [a], Iuliia A. Rusakova [a], Songhomitra Panda-Jonas [b], Ildar F. Nuriev [a], Artur F. Zaynetdinov [a], Ainur A. Zinnatullin [a], Inga I. Arslangareeva [a], Ainur V. Gizzatov [a], Natalia I. Bolshakova [a], Kamilia R. Safiullina [a], Jost B. Jonas [b,c,d,*]

[a] Ufa Eye Research Institute, Ufa, Bashkortostan, Russia
[b] Privatpraxis Prof Jonas und Dr Panda-Jonas, Heidelberg, Germany
[c] Department of Ophthalmology, Medical Faculty Mannheim. Heidelberg University, Mannheim, Germany
[d] Institute of Molecular and Clinical Ophthalmology Basel, Switzerland

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ABSTRACT

Purpose: To examine prevalence and associated factors of the metabolic syndrome (MS) in populations in Russia.
Methods: Two population-based studies (Ural Eye and Medical Study (UEMS), Ural Very Old Study (UVOS)) were conducted in rural and urban regions in Bashkortostan/Russia and included participants aged 40+ years and 85+ years, respectively.
Results: Out of 5895 UEMS participants, 1572 individuals had MS (prevalence:26.7%; 95% confidence interval (CI):25.5,27.8). The criteria of waist circumference, blood pressure, hyperglycemia, serum high-density lipoprotein concentration and serum triglyceride concentration were fulfilled by 4269 (72.4%; 95%CI:71.3,73.6), 3168 (53.7%; 95%CI:52.5,55.1), 1375 (23.3%; 95%CI:22.4,24.6), 712 (13.3%; 95%CI:12.4,14.2), and 1527 (28.6%; 95%CI:27.4,29.8) individuals, respectively. Higher MS prevalence was associated with older age (odds ratio (OR):1.03; 95%CI:1.02,1.04;$P < 0.001$), female sex (OR:1.93; 95%CI:1.51,2.47;$P < 0.001$), higher body height (OR:1.03; 95%CI:1.01,1.04;$P < 0.001$), Russian ethnicity (OR:1.38; 95%CI:1.13,1.70;$P = 0.002$), lower ankle-brachial index (OR:0.19; 95%CI:0.11,0.30;$P < 0.001$), higher prevalence of lower backache (OR:1.29; 95% CI:1.08,1.52;$P = 0.004$), cardiovascular disease (OR:2.32; 95%CI:1.92,2.78;$P < 0.001$) and thyroid disease (OR:1.41; 95%CI:1.04,1.92;$P = 0.03$), lower international normalized ratio (OR:0.55; 95%CI:0.32,0.95;$P = 0.03$), lower prevalence of current smoking (OR:0.67; 95%CI:0.50,0.89;$P = 0.006$), and higher prevalence of alcohol consumption (OR:1.35; 95%CI:1.11,1.64;$P = 0.003$). Out of 1124 UVOS participants (age:88.2 ± 2.7 years; range:85–100 years), MS was present in 485 individuals (prevalence:43.1%; 95%CI:40.3,46.1). The criteria of waist circumference, blood pressure, hyperglycemia, serum high-density lipoprotein concentration and serum triglyceride concentration were fulfilled by 853 (75.9%; 95%CI:73.4,78.4), 1057 (94.0%; 95% CI:92.7,95.4), 320 (26.9%; 95%CI:24.3,29.5), 525 (46.7%; 95%CI:43.8,49.6), and 337 (30.0%; 95%CI:27.3,32.7, individuals, respectively. Higher MS prevalence was associated with female sex (OR:2.30; 95%CI:1.72,3.09;$P < 0.001$) and higher serum concentration of aspartate transaminase (OR:1.02; 95%CI:1.01,1.03;$P = 0.007$).
Conclusions: MS is common in Russia, increases with age up to about 70 years and then plateaus, is more common in women, and differs in its associated factors between middle-aged and very old populations.

* Corresponding author. Department of Ophthalmology, Medical Faculty Mannheim, Theodor-Kutzerufer 1, 68167, Mannheim, Germany.
** Corresponding author. Ufa Eye Research Institute, 90 Pushkin Street, Ufa, 450077, Bashkortostan, Russia.
E-mail addresses: Bikbov.m@gmail.com (M.M. Bikbov), Jost.Jonas@medma.uni-heidelberg.de (J.B. Jonas).

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1. Introduction

The metabolic syndrome has been defined by the combination of abdominal obesity, insulin resistance, arterial hypertension, and hyperlipidemia [1–7]. As one of the most important risk factors for cardiovascular and cerebrovascular diseases, it forms a major part of non-communicable disorders, which have profoundly gained in importance after the marked decrease in the global prevalence of communicable diseases [8,9]. With the industrialization and associated changes in lifestyle, mainly an increase in the consumption of high calorie-low fiber fast food and a reduction in physical activity due to mechanized transportations and sedentary forms of work and leisure time activities, the MS prevalence has profoundly increased in all parts of the world [1, 2,6–9]. It is a main risk factor for type 2 diabetes, cerebrovascular and cardiovascular diseases, and other disorders [1–5,8,9]. Previous studies have examined the prevalence and associated factors of MS in numerous countries and world regions [1,2,6–9]. Despite of its importance, the MS prevalence, however, has only scarcely been investigated in Eastern Europe and Russia [9–14]. Knowledge about the frequency of MS is essential to address the disorder and improve its prevention in public health measures. We, therefore, examined the prevalence of MS and its associated factors in two populations in Russia.

2. Methods

The individuals included into the present study were the participants of the Ural Eye and Medical Study (UEMS) and the Ural Very Old Study (UVOS). The UEMS is a population-based investigation which was performed in the Russian republic of Bashkortostan at the southwestern end of the Ural Mountains in the study period from 2015 to 2017 [15]. Study regions were Ufa as capital of Bashkortostan in a distance of about 1400 km East of Moscow and a rural region in the Karmaskalinsky District in a distance of 65 km from Ufa. The republic of Bashkortostan located between the Volga River and the Ural Mountains, is the most populous republic in Russia with a population of 4 million people. Inclusion criteria for the study were living in the study regions and an age of 40 years or older. The Ethics Committee of the Academic Council of the Ufa Eye Research Institute approved the study design and confirmed that the study adhered to the Declaration of Helsinki, and all participants gave an informed written consent. As described in detail recently, out of a total group of 7328 eligible individuals, 5899 (80.5%) individuals (3319 [56.3%] women) with a mean age of 59.0 ± 10.7 years (range: 40–94 years) participated in the study [15]. The study population did not differ significantly in the gender and age distribution from the Russian population as explored in the census carried out in 2010 [16].

The UVOS is a population-based study, which was conducted in the period from 2017 to 2020 in similar, but not the same, study regions as the UEMS was performed [17]. The study was approved by the Ethics Committee of the Academic Council of the Ufa Eye Research Institute and informed written consent was obtained from all participants. Inclusion criteria were an age of 85+ years and living in the study regions. Out of 1882 eligible inhabitants aged 85+ years and living in the study regions, 1526 (81.1%) persons participated in the study. The eligible individuals included the inhabitants of three private small retirement homes in the urban study region. There were no retirement homes in the rural study region. As already described recently, the participation rate did not vary markedly between the urban group (1238 (81.3%) out of 1523 individuals) and the rural group (288 (80.2%) out of 359 individuals) [17]. According to the census carried out in Russia in 2010, the composition of the population of the UVOS with respect to gender and age corresponded to the gender and age distribution in the Russian population beyond an age of 85+ years, with a marked preponderance of females [16].

Using a bus, the study participants in both studies were brought from their homes to the Ufa Eye Institute where a team of about 20 trained ophthalmologists and technicians performed all examinations. Those UVOS participants being too immobile for the transport, were examined at their homes. As also described in detail previously, the series of examinations started with a detailed interview consisting of more than 250 standardized questions on the socioeconomic background, including the self-reported ethnicity, level of education, occupation, family income and family estate (ownership of a house and second house, telephone, smartphone, laptop, television, bicycle and car), and size and structure of the family; diet (number of meals per day, frequency and amount of intake of vegetables, fruits, whole grain and meat, consumption of tea and coffee, use of animal fat or cooking oil); smoking (since when or stopped, cigarettes or other types of tobacco products, symptoms of smoking cessation); alcohol consumption (since when or stopped, alcohol consumption-related wrongdoing); physical activity (frequency and intensity of daily work, leisure time activities, sitting or reclining); quality of life and quality of vision; symptoms of chronic obstructive pulmonary disease (COPD), asthma, kidney disease and orthopedic disorders; history of any type of injuries and inter-personal violence; and health assessment questions [15,17]. The questionnaire additionally included questions on the medical history including known diagnosis and therapy of major disorders such as diabetes mellitus, arterial hypertension, cardiovascular diseases, headache, neck pain, thoracic spine and low back pain, depression, suicidal ideas, anxiety, questions on previous neurologic attacks including stroke, epilepsy, polyneuropathy and unconsciousness, and questions on cognitive function and hearing loss. All questions included in the interview were taken from standardized interviews published in the literature, such as the “Center for Epidemiologic Studies Depression Scale (CES-D) Scoresheet”, the Folstein test, Zung’s self-rated depression scale, the National Eye Institute Visual Functioning Questionnaire-25 (VFQ-25), the Questionnaire for Verifying Stroke-Free Status (QVSFS) from the American Heart Association, and the Michigan Neuropathy Screening Instrument [15,17].

The examinations further included anthropometry, blood pressure measurement, handgrip dynamometry, spirometry, and biochemical analysis of blood samples taken under fasting conditions. We defined arterial hypertension according to the criteria published by the American Heart Association, and criteria for the diagnosis of diabetes mellitus were a fasting glucose concentration of ≥7.0 mmol/L or a self-reported history of physician diagnosis of diabetes mellitus or a history of drug treatment for diabetes (insulin or oral hypoglycemic agents). Depression was assessed by applying the Center for Epidemiologic Studies Depression Scale (CES-D) Scoresheet [18]. The estimated glomerular filtration rate (eGFR) was calculated using the chronic kidney disease (CKD) Epidemiology Collaboration (CKD-EPI) equation [19].

Using the definition of the International Diabetes Federation, MS was defined by a waist circumference of ≥94 cm in men and ≥80 cm in women, and at least two of the four following conditions: a blood glucose concentration of >5.6 mmol/L or the diagnosis of diabetes mellitus, a serum concentration of high-density cholesterol of <1.0 mmol/L in men and <1.3 mmol/L in women or specific drug treatment of hyperlipidemia; serum triglyceride concentration of >1.7 mmol/L or specific drug treatment of hyperlipidemia, and an arterial blood pressure of >130/85 mmHg or specific drug treatment of arterial hypertension [20]. We applied the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER statement guidelines) [21].

Using a statistical software package (SPSS for Windows, version 27.0, SPSS, Chicago, IL), we determined the prevalence of MS (presented as mean and 95% confidence intervals (CIs)) and performed a binary regression analysis of the relationships between the MS prevalence and other systemic parameters. It was followed by multivariable regression analysis with the MS prevalence as the dependent parameter and as independent variables, all those parameters significantly correlated with the MS prevalence in the univariate analyses. We dropped, in a step-by-step manner out of the list of independent parameters those variables that showed collinearity with other parameters, and then those parameters that were no longer significantly associated with the MS prevalence. We calculated the odds ratios (ORs) and their 95% CIs. All *P*-

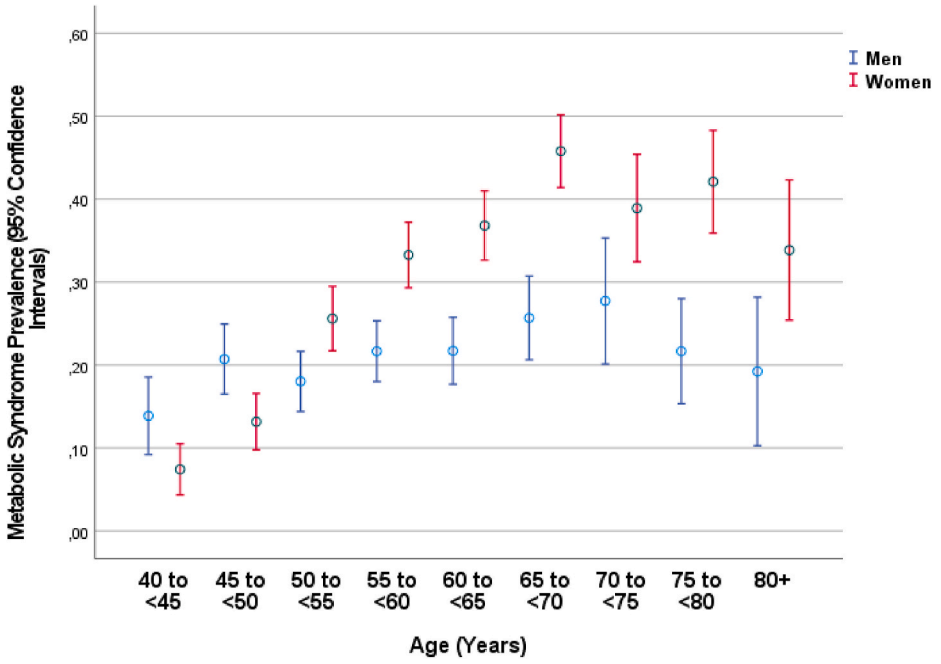

Fig. 1. Graph showing the prevalence of metabolic syndrome stratified by age and sex in the Ural Eye and Medical Study.

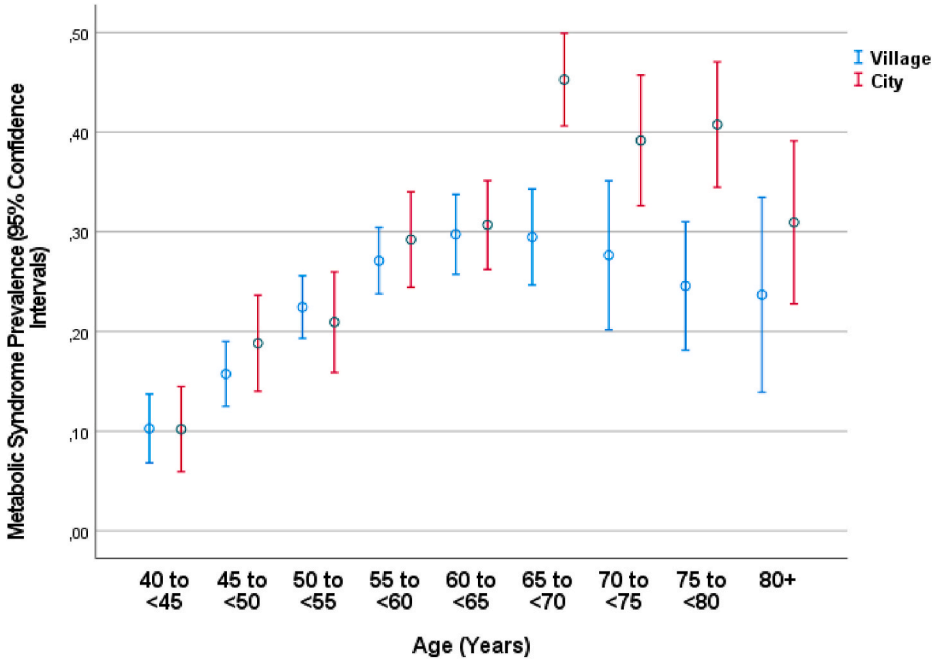

Fig. 2. Graph showing the prevalence of metabolic syndrome stratified by age and region of habitation in the Ural Eye and Medical Study.

values were two-sided and considered statistically significant when the values were less than 0.05.

3. Results

3.1. Ural Eye and Medical Study

Out of 5899 participants of the Ural Eye and Medical Study, measurements of the basic parameters for the assessment of MS were available for 5895 (99.9%) individuals (2578 (43.7%) men) with a mean age: 59.0 ± 10.7 years; range: 40–94 years. The study participants included 1185 (20.1%) Russians, 1061 (18.0%) Bashkirs, 2439 (41.4%) Tartars, 587 (10.0%) Chuvash, 21 (0.4%) Mari, and 602 (10.2%) other or undefined ethnic groups.

MS was present in 1572 of the study participants with a prevalence of 26.7% (95%CI: 25.5, 27.8). There were 541 (21.0%) out of 578 men and 1031 (31.1%) out of 3317 women affected by MS. The prevalence of MS was 799/3400 (23.5%) in the rural region and 773/2495 (31.0%) in the urban area. Out of the overall 5895 participants, 4269 (72.4%; 95%CI: 71.3, 73.6) fulfilled the criterion of waist circumference, 3168 (53.7%; 95%CI: 52.5, 55.1) the criterion of blood pressure, 1375 (23.3%; 95% CI:22.4, 24.6) the criterion of blood glucose concentration, 712 (13.3%; 95%CI: 12.4, 14.2) the criterion of serum high-density lipoprotein concentration, and 1527 (28.6%; 95%CI: 27.4, 29.8) the criterion of

Table 1
Associations (univariable analysis) between the prevalence of metabolic syndrome and other parameters in the Ufa Eye and Medical Study.

Parameter	Odds ratio	95% confidence interval	*P*-Value
Age (years)	1.03	1.03, 1.04	<0.001
Men/women	1.70	1.51, 1.92	<0.001
Rural/urban region of habitation	1.46	1.30, 1.64	<0.001
Family status: Married/Unmarried/ Divorced/Widowed/Missing	1.20	1.14, 1.26	<0.001
Family status: Married versus any other status	0.71	0.62, 0.80	<0.001
Family type: Joint (three generations)/ nuclear (two generations)/single/ family of 2 people	0.98	0.93, 1.03	0.33
Religion: Muslim/Christian/Other	1.09	0.98, 1.22	0.11
Religion: Muslim/any other religion	0.90	0.80, 1.01	0.07
Ethnicity: Russian/Bashkirs/Tatars/ Chuvash/Mari/Others/Missing	0.87	0.82, 0.92	<0.001
Ethnicity: Russian/any other ethnicity	1.62	1.41, 1.86	<0.001
Body height (cm)	0.98	0.98, 0.99	<0.001
Body weight (kg)	1.04	1.04, 1.05	<0.001
Body mass index (**kg**/m^2)	1.16	1.14, 1.17	<0.001
Waist circumference (cm)	1.08	1.07, 1.08	<0.001
Hip circumference cm)	1.06	1.06, 1.07	<0.001
Waist/hip circumference ratio	69.6	35.7, 135.9	<0.001
Systolic blood pressure (mmHg)	1.04	1.03, 1.04	<0.001
Diastolic blood pressure (mmHg)	1.05	1.05, 1.06	<0.001
Mean blood pressure (mmHg)	1.06	1.05, 1.06	<0.001
Ankle-brachial index, right side	0.23	0.14, 0.37	<0.001
Ankle-brachial index, left side	0.28	0.18, 0.44	<0.001
Socioeconomic parameters			
Level of education	0.98	0.94, 1.02	0.39
Monthly Income (Below poverty line/ average/above average/high)	1.07	0.95, 1.20	0.29
Socioeconomic score	0.97	0.93, 1.01	0.11
Physical activity score	0.98	0.97, 0.98	<0.001
History of diseases			
History of headache	1.30	1.15, 1.46	<0.001
History of neck pain	1.23	1.08, 1.40	0.002
History of thoracic spine pain	1.39	1.21, 1.60	<0.001
History of back pain	1.31	1.16, 1.48	<0.001
History of therapy of hyperlipidemia	24.4	18.2, 32.8	<0.001
History of cancer	1.34	0.97, 1.85	0.07
History of cardiovascular disorders including stroke	2.54	2.24, 2.89	<0.001
History of dementia	1.45	0.74, 2.86	0.28
History of diabetes mellitus	11.3	9.11, 14.0	<0.001
History of diarrhea	1.84	0.85, 3.98	0.12
History of bone fracture	1.08	0.95, 1.22	0.27
History of heart attack	2.29	1.82, 2.88	<0.001
History of iron-deficiency anemia	1.15	0.89, 1.48	0.28
History of low blood pressure and hospital admittance	1.56	1.17, 2.07	0.002
History of skin disease	1.28	0.99, 1.65	0.06
History of use of steroids	0.71	0.31, 1.64	0.42
History of thyroid disease	1.63	1.36, 1.94	<0.001
History of tumbling	1.26	1.09, 1.45	<0.001
History of unconsciousness	1.18	0.97, 1.45	0.10
Age of the last menstrual bleeding (years)	1.01	0.99, 1.03	0.32
Age of last regular menstrual bleeding (years)	1.01	0.99, 1.03	0.33
Menopause	3.98	3.07, 5.16	<0.001
Blood concentrations (mmol/L) of:			
Alanine aminotransferase (ALT) (IU/L)	1.008	1.003, 1.012	0.002
Aspartate aminotransferase (AST) (IU/L)	1.008	1.002, 1.013	0.005
AST/ALT ratio	0.95	0.77, 1.17	0.61
Bilirubin, total (μmol/L)	1.00	0.99, 1.00	0.40
High-density lipoproteins (mmol/L)	0.68	0.63, 0.74	<0.001
Low-density lipoproteins (mmol/L)	0.99	0.94, 1.04	0.77
Triglycerides (mmol/L)	4.19	3.75, 4.69	<0.001
Cholesterol (mmol/L)	1.13	1.09, 1.17	<0.001
Erythrocyte sedimentation rate (mm/ hour)	1.01	1.01, 1.02	<0.001
Glucose (mmol/L)	1.71	1.62, 1.79	<0.001
Creatinine (μmol/L)	1.002	1.000, 1.004	0.12
Urea (mmol/L)	1.07	1.03, 1.11	0.001
Residual nitrogen (g/L)	1.49	0.70, 3.18	0.30
Total protein (g/L)	1.01	1.00, 1.02	0.21
International normalized ratio (INR)	0.49	0.32, 0.74	0.001
Blood clotting time (minutes)	0.91	0.82, 1.01	0.08
Prothrombin index (%)	1.01	1.003, 1.02	0.002
Hemoglobin (g/dL)	1.00	1.00, 1.00	0.79
Erythrocytes (10^6 cells/μL)	0.94	0.81, 1.10	0.43
Leukocytes (10^9 cells/L)	1.10	1.06, 1.14	<0.001
Diet			
Vegetarian diet/mixed diet	3.28	0.42, 25.9	0.26
Number of meals per day	1.13	1.05, 1.21	0.001
In a week how many days do you eat fruits?	1.02	0.99, 1.05	0.28
In a week how many days do you eat vegetables?	0.99	0.95, 1.03	0.62
Type of oil used for cooking: vegetable oil/ non-vegetable oil	0.94	0.74, 1.18	0.58
Food containing whole grains (Yes/No)	1.01	0.87, 1.17	0.93
Salt consumed per day (g)	0.99	0.97, 1.02	0.44
Degree of processing of meat (weak/ medium/well done)	0.96	0.86, 1.08	0.51
Miscellanea			
Do you currently smoke any tobacco products? (yes)	0.48	0.39, 0.59	<0.001
Package years (package = 20 cigarettes)	0.98	0.98, 0.99	<0.001
Alcohol consumed such as beer, whisky, rum, gin brandy or other local products? (yes/no)	0.86	0.74, 0.99	0.04
Hearing Loss Total Score	1.007	1.002, 1.013	0.006
Depression score	1.03	1.01, 1.05	<0.001
State-Trait Anxiety Inventory (STAI) score	1.04	1.02, 1.05	<0.001
Manual dynamometry, right hand (dekaNewton)	0.98	0.97, 0.98	<0.001
Manual dynamometry, left hand (dekaNewton)	0.98	0.97, 0.98	<0.001

serum triglyceride concentration.

In univariable analysis, a higher MS prevalence was associated with older age (Fig. 1), female sex (Fig. 1), urban region of habitation (Fig. 2), higher prevalence of a widowed family status, Russian ethnicity, lower body height, lower ankle-brachial index, lower physical activity score, higher prevalence of a positive history of headache, neck pain, thoracic spine and lower back pain, cardiovascular disease including stroke, heart attack, low blood pressure and hospital admittance, thyroid disease, falls and menopause, higher serum concentrations of alanine aminotransferase, aspartate aminotransferase and urea, higher prothrombin index, lower International normalized ratio (INR), higher erythrocyte sedimentation rate, and lower leucocyte cell count, higher number of daily meals, higher prevalence of current smoking, higher smoking package years, lower prevalence of any alcohol consumption, higher hearing loss score, depression score, State-Trait Anxiety Inventory score, and lower dynamometric handgrip strength. (Table 1).

In the multivariable analysis we dropped due to collinearity the parameter of left ankle-brachial index. Due to a lack of statistical significance, we dropped in a step-by-step manner the parameters of prothrombin index ($P = 0.96$), depression score ($P = 0.91$), anxiety score ($P = 0.92$), serum concentrations of urea ($P = 0.98$) and alanine aminotransferase ($P = 0.99$), erythrocyte sedimentation rate ($P = 0.58$), history of thoracic spine pain ($P = 0.48$), headache ($P = 0.38$) and neck pain ($P = 0.37$), history of low blood pressure and hospital admittance ($P = 0.43$), number of daily meals ($P = 0.53$), smoking package years ($P = 0.37$), physical activity score ($P = 0.73$), family status ($P = 0.44$), married versus any other family status ($P = 0.44$), hearing loss score ($P = 0.40$), history of falls ($P = 0.14$), dynamometric handgrip strength ($P = 0.11$), blood leucocyte count ($P = 0.06$), serum concentration of aspartate aminotransferase ($P = 0.07$), and region of habitation ($P = 0.06$). In the final model, a higher MS prevalence was associated with older age, female sex, higher body height, Russian ethnicity, lower

Table 2
Associations (multivariable analysis) between the prevalence of metabolic syndrome and other parameters in the Ufa Eye and Medical Study.

Parameter	Odds ratio	95% confidence interval	*P*-Value
Age (years)	1.03	1.02, 1.04	<0.001
Men/women	1.93	1.51, 2.47	<0.001
Body height (cm)	1.03	1.01, 1.04	<0.001
Russian ethnicity (no/yes)	1.38	1.13, 1.70	0.002
Ankle-brachial index	0.19	0.11, 0.30	<0.001
History of backache	1.29	1.08, 1.52	0.004
History of cardiovascular disease including stroke	2.32	1.92, 2.78	<0.001
History of thyroid disease	1.41	1.04, 1.92	0.03
International normalized ratio (INR)	0.55	0.32, 0.95	0.03
Current smoking	0.67	0.50, 0.89	0.006
Any alcohol consumption	1.35	1.11, 1.64	0.003

ankle-brachial index, higher prevalence of a history of lower backache, cardiovascular disease including stroke, and thyroid disease, a lower international normalized ratio (INR), lower prevalence of current smoking and higher prevalence of any alcohol consumption (Table 2).

3.2. Ural Very Old Study

Out of 1526 participants of the Ural Very Old Study, information about the presence of MS was available for 1124 (73.7%) individuals (299 (26.6%) men) with a mean age: 88.2 ± 2.7 years; range: 85–100 years. The study participants included 399 (35.5%) Russians, 132 (11.7%) Bashkirs, 492 (43.8%) Tatars, 43 (3.8%) Chuvash, 6 (0.5%) Mari, and 52 (4.6%) other or undefined ethnic groups.

MS was present in 485 of the 1124 study participants with a prevalence of 43.1% (95%CI: 40.3, 46.1). There were 87 (29.1%) out of 299 men and 398 (48.2%) out of 825 women affected by MS. The prevalence of MS was 119/68 (44.4%) in the rural region and 366/856 (42.8) in the urban area. Out of the 1124 participants, 853 (75.9%; 95%CI: 73.4, 78.4) fulfilled the criterion of waist circumference, 1057 (94.0%; 95% CI: 92.7, 95.4) the criterion of blood pressure, 320 (26.9%; 95%CI: 24.3, 29.5) the criterion of blood glucose concentration, 525 (46.7%; 95%CI: 43.8, 49.6) the criterion of serum high-density lipoprotein concentration, and 337 (30.0%; 95%CI: 27.3, 32.7) the criterion of serum triglyceride concentration.

In univariable analysis, a higher OA prevalence was associated with female sex (Fig. 3), higher prevalence of a positive history of cardiovascular disease including stroke, lower prevalence of a history of diarrhea, lower blood concentrations of aspartate aminotransferase and low-density lipoproteins, higher number of days with vegetable consumption, lower number of cups of coffee taken daily, lower prevalence of any alcohol consumption, and lower dynamometric handgrip strength (Table 3). MS prevalence was not significantly ($P = 0.98$) associated with age (Fig. 3).

In the multivariable analysis we dropped due to a lack of statistical significance, we dropped the parameters of history of diarrhea ($P = 0.53$), dynamometric handgrip strength ($P = 0.74$), number of cups of coffee taken daily ($P = 0.08$), prevalence of any alcohol consumption ($P = 0.20$), and prevalence of a positive history of cardiovascular disease including stroke ($P = 0.21$). In the final model, a higher MS prevalence was associated with female sex (OR: 2.30; 95%CI: 1.72, 3.09; $P < 0.001$), higher serum concentration of aspartate transaminase (OR: 1.02; 95% CI: 1.01, 1.03; $P = 0.007$), and a higher number of days with vegetable intake (OR: 1.11; 95%CI: 1.03, 1.20; $P = 0.009$).

4. Discussion

In our middle-aged UEMS study population, the MS prevalence was 26.7%. Besides an abnormally high waist circumference, found in 72.4% of the study population, an abnormally high blood pressure (53.7%) was the most common criterion for the definition of MS, followed by the criterion of an abnormally high serum triglyceride concentration (28.6%), the parameter of an abnormally high blood glucose concentration (23.3%), and finally the criterion of an abnormally low serum high-density lipoprotein concentration (13.3%). A higher MS prevalence was associated with factors such as older age, female sex, higher body height, Russian ethnicity, lower ankle-brachial index, higher prevalence of a history of lower backache, cardiovascular disease including stroke and thyroid disease, a lower INR, lower prevalence of current smoking and higher prevalence of any alcohol consumption. In the very old population of the UVOS, the MS prevalence was 43.1%. Besides an abnormally high waist circumference, found in 75.9% of the study

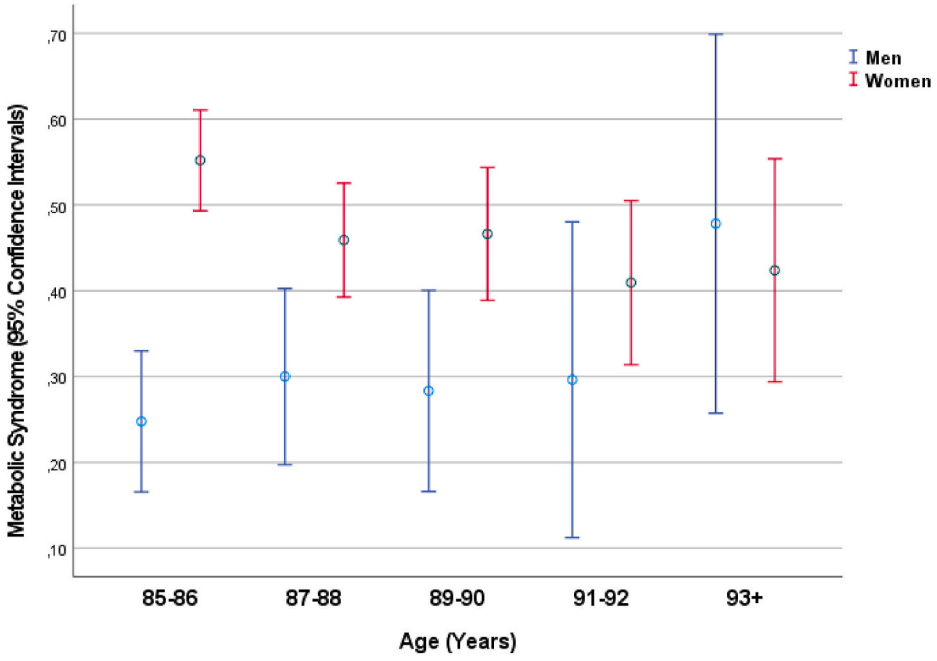

Fig. 3. Graph showing the prevalence of metabolic syndrome stratified by age and sex in the Ural Very Old Study.

Table 3
Associations (univariable analysis) between the prevalence of metabolic syndrome and other parameters in the Ural Very Old Study.

Parameter	Odds ratio	95% confidence interval	*P*-Value
Age (years)	0.98	0.93, 1.02	0.26
Men/women	2.27	1.71, 3.02	<0.001
Rural/urban region of habitation	0.94	0.71, 1.23	0.64
Family status: Married/Unmarried/Divorced/Widowed/Missing	1.03	0.94, 1.14	0.49
Family status: Married versus any other status	0.87	0.65, 1.16	0.33
Family type: Joint (three generations)/nuclear (two generations)/single/family of 2 people	0.98	0.88, 1.10	0.78
Religion: Muslim/Christian/Other	1.11	0.89, 1.40	0.36
Religion: Muslim/any other religion	0.94	0.74, 1.20	0.62
Ethnicity: Russian/Bashkirs/Tatars/Chuvash/Mari/Others/Missing	1.03	0.92, 1.16	0.58
Ethnicity: Russian/any other ethnicity	0.96	0.75, 1.23	0.75
Body height (cm)	0.99	0.98, 1.01	0.33
Body weight (kg)	1.04	1.02, 1.05	<0.001
Body mass index (kg/m^2)	1.12	1.08, 1.15	<0.001
Waist circumference (cm)	1.07	1.06, 1.08	<0.001
Hip circumference cm)	1.05	1.04, 1.06	<0.001
Waist/hip circumference ratio	145.3	31.1, 678.0	<0.001
Systolic blood pressure (mmHg)	1.005	1.001, 1010	0.03
Diastolic blood pressure (mmHg)	1.001	0.999, 1.016	0.09
Mean blood pressure (mmHg)	1.008	1.001, 1.016	0.03
Ankle-brachial index, right side	0.54	0.08, 3.71	0.53
Ankle-brachial index, left side	0.37	0.06, 2.53	0.31
Socioeconomic parameters			
Level of education	0.99	0.93, 1.04	0.60
Monthly Income (Below poverty line/average/above average/high)	0.89	0.69, 1.16	0.39
Socioeconomic score	1.00	0.95, 1.05	0.87
Physical activity score	1.06	0.83, 1.35	0.66
History of diseases			
History of headache	1.02	0.81, 1.30	0.84
History of neck pain	0.95	0.71, 1.29	0.75
History of thoracic spine pain	0.91	0.71, 1.17	0.46
History of back pain	1.12	0.87, 1.43	0.38
History of therapy of hyperlipidemia	0.22	0.12, 0.40	<0.001
History of cancer	1.23	0.80, 1.89	0.36
History of cardiovascular disorders including stroke	1.52	1.05, 2.22	0.03
History of dementia	0.88	0.55, 1.41	0.60
History of diabetes mellitus	7.86	4.67, 1.2	<0.001
History of diarrhea	0.22	0.05, 0.97	0.046
History of bone fracture	0.98	0.77, 1.26	0.88
History of heart attack	0.88	0.62, 1.24	0.45
History of iron-deficiency anemia	1.28	0.71, 2.29	0.41
History of low blood pressure and hospital admittance	0.60	0.23, 1.59	0.30
History of skin disease	1.29	0.77, 2.17	0.33
History of use of steroids	0	0	0.99
History of thyroid disease	0.88	0.55, 1.41	0.60
History of tumbling	1.15	0.91, 1.46	0.25
History of unconsciousness	1.04	0.70, 1.55	0.84
Age of the last menstrual bleeding (years)	0.99	0.95, 1.02	0.44
Age of last regular menstrual bleeding (years)	0.99	0.95, 1.03	0.54
Blood concentrations (mmol/L) of:			
Alanine aminotransferase (ALT) (IU/L)	1.009	0.995, 1.023	0.20
Aspartate aminotransferase (AST) (IU/L)	1.014	1.002, 1.027	0.02
AST/ALT ratio	0.98	0.90, 1.06	0.56
Bilirubin, total (μmol/L)	0.99	0.97, 1.001	0.06
High-density lipoproteins (mmol/L)	0.59	0.50, 0.70	<0.001
Low-density lipoproteins (mmol/L)	1.16	1.04, 1.31	0.01
Triglycerides (mmol/L)	3.96	3.10, 5.05	<0.001
Cholesterol (mmol/L)	1.05	0.96, 1.15	0.30
Erythrocyte sedimentation rate (mm/hour)	1.01	0.999, 1.02	0.07
Glucose (mmol/L)	1.33	1.21, 1.47	<0.001
Creatinine (μmol/L)	1.00	0.995, 1.01	0.90
Urea (mmol/L)	1.02	0.96, 1.07	0.58
Residual nitrogen (g/L)	1.79	0.31, 10.4	0.52
Total protein (g/L)	1.01	0.99, 1.02	0.35
International normalized ratio (INR)	1.65	0.65, 4.18	0.29
Blood clotting time (minutes)	0.85	0.62, 1.15	0.28
Prothrombin index (%)	0.99	0.98, 1.003	0.14
Hemoglobin (g/dL)	0.997	0.991, 1.004	0.42
Erythrocytes (10^6 cells/μL)	0.89	0.71, 1.12	0.31
Leukocytes (10^9 cells/L)	1.02	0.95, 1.10	0.55
Diet			
Vegetarian diet/mixed diet	–	–	–
Number of meals per day	1.07	0.92, 1.24	0.40
In a week how many days do you eat fruits?	1.05	0.99, 1.12	0.09
In a week how many days do you eat vegetables?	1.08	1.01, 1.17	0.04
Type of oil used for cooking: vegetable oil/non-vegetable oil	1.14	0.85, 1.52	0.40
Food containing whole grains (Yes/No)	0.99	0.59, 1.65	0.96
Salt consumed per day (g)	0.92	0.92, 1.04	0.45
Degree of processing of meat (weak/medium/well done)	1.04	0.85, 1.27	0.71
Number of cups of coffee per day	0.74	0.58, 0.96	0.02
Number of cups of tea per day	1.09	0.98, 1.21	0.12
Miscellanea			
Do you currently smoke any tobacco products? (yes)	6.90	0.87, 54.6	0.07
Alcohol consumed such as beer, whisky, rum, gin brandy or other local products? (yes/no)	0.56	0.38, 0.82	0.003
Hearing Loss Total Score	0.98	0.92, 1.05	0.53
Depression score	1.00	0.99, 1.02	0.53
State-Trait Anxiety Inventory (STAI) score	1.01	0.995, 1.02	0.27
Manual dynamometry, right hand (dekaNewton)	0.98	0.96, 0.996	0.01
Manual dynamometry, left hand (dekaNewton)	0.98	0.96, 0.995	0.01

population, an abnormally high blood pressure (94.0%) was by far the most common criterion for the definition of MS, followed by the parameter of an abnormally low serum high-density lipoprotein concentration (46.7%), the criterion of an abnormally high serum triglyceride concentration (30.0%), and finally the parameter of an abnormally high blood glucose concentration (26.9%). A higher MS prevalence was associated with female sex, higher serum concentration of aspartate transaminase, and a higher number of days with vegetable intake.

The findings obtained in both of our studies agree with observations made in previous investigations addressing the prevalence of MS in other study populations worldwide. Using 2003–2012 NHANES (National Health and Nutrition Examination Survey) data, Aguilar and colleagues found for the United States an MS prevalence (defined by the National Cholesterol Education Program Adult Treatment Panel III) of 33% in the period from 2003 to 2012, with a significantly higher prevalence in women than in men (35.6% vs 30.3%) [22]. The MS prevalence was highest in Hispanics (35.4%), followed by non-Hispanic whites (33.4%) and blacks (32.7%). From 2003 to 2004 to 2011–2012, the MS prevalence increased from 32.9% to 34.7%. The MS prevalence increased with older age, from 18.3% among those aged 20–39 years to 46.7% among those aged 60+ years, with more than 50% of women and Hispanics in the latter age group having MS [22]. Conducting a meta-analysis, Ansarimoghaddam and associates found a pooled estimate of the MS prevalence of 25% in Middle-East countries [23]. In another meta-analysis, Li and colleagues found in China an MS prevalence among subjects aged 15+ years a pooled MS prevalence of 24.5%, with higher rates in women than in men (27.0% versus 19.2%) [24]. The MS prevalence increased with older age (from 13.9% in the age group of 15–39 years, to 26.4% in the age group of 40–59 years, and to 32.4% in individuals aged 60+ years), and it was higher in urban than in rural regions (24.9% versus 19.2%). Arterial hypertension was the most common prevalent component of MS in men (52.8%), while it was

central obesity in women (46.1%). The data found in our study populations also agree with findings obtained in previous studies on smaller and partially selected populations from Russia, with figures of a MS prevalence of 41.7% in women and 26.8% in men among Muscovites aged 55+ years [9–14]. In that study population, the MS prevalence decreased with older age in men, but not so in women. The MS prevalence was inversely related to the level of education in women, but not in men. The most common components of MS in women were arterial hypertension (64.4%), followed by abdominal obesity (55%), an abnormally low high-density lipoprotein cholesterol concentration (46%), and finally an elevated serum triglyceride concentration (23.5%), and in men it was arterial hypertension (71%) followed by hyperglycemia (35.2%), and finally an elevated serum triglyceride concentration (22.1%) [12]. In the study conducted by Alieva and colleagues, the MS in the study population with a mean age of 55 years was 43% [14].

Interestingly, the MS prevalence did not further increase with age in the elderly population of the UVOS. In the UVOS, as compared to the younger population of the UEMS, there was no association between the MS prevalence and factors such as higher body height, Russian ethnicity, lower ankle-brachial index, higher prevalence of a history of lower backache, cardiovascular disease including stroke and thyroid disease, a lower INR, lower prevalence of current smoking and higher prevalence of any alcohol consumption (Table 2). One may discuss that the MS-associated increased mortality might have led to a selection of survivors who were not markedly susceptible for the negative sequels of MS-associated parameters. It leads to the question whether in the age group of 85+ years, MS is as strongly associated with increased morbidity and mortality as it is in the younger age groups.

The relatively high prevalence of MS of 26.7% in the UEMS population and of 43.1% in the UVOS shows the importance of MS for public health in Russia, as also shown for other world regions.[1,2,8,9,22–25] It agrees with the results of the recent analyses of the Global Burden of Disease Study in which obesity as a major parameter for MS was one of the most important causes of years lived with disability (YLDs) [7–9].

When results of our study are discussed, its limitations should be considered. First, when the findings of investigations on different study populations are compared with each other, differences in the composition of the study populations with respect to the factors associated with the OA prevalence should be considered. These factors include the parameters of age, sex, BMI, inclusion and exclusion criteria, study period and quality of the medical infrastructure. Second, the participation rate in the UVOS was relatively low, with 1526 (81.1%) out of 1882 eligible inhabitants participating in the study, and with 1238 (81.3%) of these 1582 individuals having measurements as basis for the assessment of the MS. However, it may be taken into account, that in the old age group of 85+ years, the mobility of individuals is markedly decreased, reducing the possibility of individuals participating in studies. Strengths of our project were that the MS prevalence has not often been assessed yet in Eastern Europe and Russia, and that the UVOS is one of the only few studies worldwide including a very old population with an age of 85+ years.

5. Conclusions

MS is common in Russia, increases with age up to about 70 years and then plateaus, is more common in women, and differs in its associated factors between middle-aged and very old populations.

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Author contributions

Design of the study: MMB, GMK, JBJ; Data collection: MMB, GMK, TRG, RMZ, EMI, AAF, AMT, IAR, SPJ, IFN, AFZ, AZN, IIA, AVG, NIB, KRS, JBJ, Organization and surveillance: MMB, GMK; Statistical analysis: JBJ, SPJ; Drafting the first version of the manuscript: JBJ, SPJ; Modifying and approving the final version of the manuscript: MMB, GMK, TRG, RMZ, EMI, AAF, AMT, IAR, SPJ, IFN, AFZ, AZN, IIA, AVG, NIB, KRS, JBJ.

Declaration of competing interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.metop.2022.100183.

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