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Supernormal vascular aging — prevalence and determinants at population level (the ESSE-RF data)

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Abstract

Background. Arterial stiffness, which is a marker of vascular damage and cardiovascular disease independent predictor, can be used as an indicator of vascular aging. Vascular changes may occur in some individuals earlier than it comes according to chronological age (early vascular aging syndrome) or later (healthy aging). SUPERNOVA (supernormal vascular aging) is a new protective phenotype in which very low arterial stiffness values are recorded regardless of the level of risk factors exposure. **Objective.** To assess the prevalence of SUPERNOVA phenomenon and risk factors in St Petersburg population-based sample. **Design and methods.** The survey of 1600 St Petersburg residents aged 24–65 years was performed in terms of the epidemiological observation study ESSE-RF (2012–2013). Anthropometry and fasting blood sampling for lipids and glucose detection and blood pressure measurement according to standard methods were performed. Pulse wave velocity (PWV) assessed by SphygmoCor (Australia) was performed in 524 people. 485 participants were selected without cardiovascular complications history. The participants were divided by age into 5 groups: persons under 30 years, 30–39 years, 40–49 years, 50–59 years, 60 years and older. PWV ≤ 10^{th} percentiles for healthy individuals PWV (Reference Values for Arterial Stability's Collaboration, 2010) was detected as SUPERNOVA phenomenon in each age group. Mathematical and statistical data analysis was implemented using IBM SPSS Statistics 20.0. **Results.** SUPERNOVA phenomenon prevalence was 9.8% (48 participants): 11.9% women (32 participants) and 7.4% men (16 participants). Among women systolic blood pressure (SBP) levels (p = 0.01) and body mass index (BMI) (p = 0.055) were significantly lower. Persons with SUPERNOVA showed significantly lower SBP and diastolic blood pressure (DBP), BMI, glucose, triglycerides and lower prevalence of arterial hypertension (HTN), obesity, hypercholesterolemia and hypertriglyceridemia. In participants younger 30 years only obesity prevalence was significantly lower in respondents with SUPERNOVA, based on BMI criterion (p = 0.046). Participants aged 30–39 years showed no significant differences. In the group aged 40–49 years BMI (p = 0.02), abdominal obesity prevalence (p = 0.05), as well as SBP levels (p = 0.03) and DBP (p = 0.05) was significantly lower in individuals with SUPERNOVA. In the group aged 50–59 with SUPERNOVA significantly lower HTN prevalence (p = 0.03), glucose levels (p = 0.005) and BMI (p = 0.04) were found. In the older age group of 60–65 years subjects with SUPERNOVA have significantly lower levels of SBP (p = 0.014) and DBP (p = 0.014), as well as significantly

lower prevalence of HTN (p = 0.03). **Conclusions.** At population level the phenomenon of supernormal vascular aging occurs in about 10% without significant gender prevalence. HTN, obesity and metabolic factors are the determining factors of vascular aging. Ideal vascular health is associated with age-specific features.

Key words: SUPERNOVA, systolic blood pressure, diastolic blood pressure, hypertension, diabetes mellitus, body mass index

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Концепция «супернормального» сосудистого старения — распространенность и детерминанты на популяционном уровне (в рамках ЭССЕ-РФ)

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Резюме

Актуальность. Артериальная жесткость, которая является маркером поражения сосудов и независимым предиктором сердечно-сосудистых заболеваний, может использоваться в качестве показателя сосудистого старения. Изменения сосудов в рамках сосудистого старения могут возникать у некоторых индивидуумов раньше, чем положено согласно хронологическому возрасту (синдром преждевременного старения сосудов), или позже (здоровое старение). SUPERNOVA («супернормальное» сосудистое старение) — новый защитный фенотип, при котором регистрируются очень низкие значения артериальной жесткости независимо от уровня воздействия факторов риска. **Цель исследования** — оценить распространенность феномена SUPERNOVA и факторов, влияющих на его развитие, в популяционной выборке жителей Санкт-Петербурга. **Материалы и методы.** Обследование популяционной выборки из 1600 жителей Санкт-Петербурга в возрасте 24–65 лет выполнено в рамках эпидемиологического наблюдательного исследования ЭССЕ-РФ в 2012–2013 годах. Проводились антропометрия, взятие крови натощак для определения уровня липидов и глюкозы, измерение артериального давления согласно стандартным методикам. Оценка скорости распространения пульсовой волны (СРПВ) с помощью аппарата SphygmoCor (Австралия) выполнена у 524 человек, по результатам которой были отобраны 485 участников без сердечно-сосудистых осложнений в анамнезе. Исследуемые были разделены по возрасту на 5 групп: лица до 30 лет, 30–39 лет, 40–49 лет, 50–59 лет, от 60 лет и старше. За критерий наличия феномена SUPERNOVA в каждой возрастной группе принималось значение СРПВ равное или менее 10-го перцентиля СРПВ для

здоровых лиц (Reference Values for Arterial Stiffness's Collaboration, 2010). Математико-статистический анализ данных реализовывался с использованием программы IBM SPSS Statistics 20.0. **Результаты.** Распространенность феномена SUPERNOVA составила 9,8% (48 человек): у 11,9% женщин (32 человека) и 7,4% мужчин (16 человек). У женщин был значимо ниже уровень систолического артериального давления (САД) (p = 0,01) и индекс массы тела (ИМТ) (p = 0,055). При наличии феномена SUPERNOVA отмечены существенно более низкие показатели САД и диастолического артериального давления (ДАД), ИМТ, глюкозы, триглицеридов и меньшая распространенность артериальной гипертензии (АГ), ожирения, гиперхолестеринемии и гипертриглицеридемии. В группе лиц менее 30 лет значимо ниже только распространенность ожирения у респондентов с феноменом SUPERNOVA по критерию ИМТ (p = 0,046), а в группе лиц 30–39 лет не было выявлено значимых различий. В группе 40–49 лет значимо ниже ИМТ (p = 0,02) и распространенность абдоминального ожирения (p = 0,05), а также уровень САД (p = 0,03) и ДАД (p = 0,05) у лиц с SUPERNOVA. В группе лиц 50–59 лет с SUPERNOVA выявлены значимо более низкие распространенность АГ (p = 0,03), уровень глюкозы (p = 0,005) и ИМТ (p = 0,04). В старшей возрастной группе 60–65 лет у лиц с SUPERNOVA зарегистрированы значимо более низкий уровень САД (p = 0,014) и ДАД (p = 0,014), а также сохраняется значимо более низкая распространенность АГ (p = 0,03). **Вывод.** На популяционном уровне феномен «супернормального» старения сосудов встречается примерно в 10% случаев без значимого гендерного преобладания. АГ, ожирение и метаболические факторы являются определяющими факторами, вызывающими старение с наличием возрастных особенностей сохранения идеального состояния сосудов.

Ключевые слова: синдром «супернормального» сосудистого старения, систолическое артериальное давление, диастолическое артериальное давление, артериальная гипертензия, сахарный диабет, индекс массы тела, холестерин

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Background

Prevalence of most cardiovascular diseases increases markedly with age, which is actually the most important factor of cardiovascular risk in majority risk assessment scales. Vascular changes within vascular aging may occur earlier than usual according to chronological age (early vascular aging syndrome, EVA syndrome) or later (normal biological aging). According to the famous expression of Thomas Sydenham, "a man is as old as his arteries" nowadays arterial stiffness is considered a "barometer" of biological or physiological aging [1]. Data collected over the past two decades shows that arterial stiffness, which is a marker of vascular damage and is an independent predictor of cardiovascular disease (CVD) can be used as an indicator of vascular aging [2,3].

A leading expert in this field, Stephan Laurent and collaborators, in their recent review in 2019, suggested a new protective phenotype — SUPERNOVA (supernormal vascular aging), in which very low values of arterial stiffness are registered regardless of the level of exposure to risk factors. The authors believe that exposure to cardiovascular risk factors does not always lead to subclinical organ damage and cardiovascular complications. Subjects with the SUPERNOVA represent an area for scientific research in which it is necessary to identify protective mechanisms and consider them as a potential therapeutic target in the future. There are no studies on the prevalence of the SUPERNOVA and its predictors at the population level [4].

The purpose of our study was to assess the prevalence of the SUPERNOVA phenomenon and the factors influencing its development in a group of residents of Saint Petersburg.

Materials and methods

Within the multicenter observational study "Epidemiology of cardiovascular diseases in the regions of the Russian Federation" a random cohort of 1600 residents of St. Petersburg of both sexes aged 24–65 years was examined. Each participant signed an informed consent to conduct the survey and was interviewed on questionnaires developed on the basis of adapted international methods, consisting of 12 modules [5].

The body weight was measured on the scales of the VEM-150-Mass-K (Russia), height— using the height meter RM-1 Diacoms (Russia), waist and hips circumference (WC and HC, respectively)— using a standard measuring tape. Groups of individuals with abdominal obesity were formed according to the criteria for metabolic syndrome (MS) of the IDF 2005: men and women with waist circumference of ≥ 94 cm and

≥ 80 cm, respectively. The body mass index (BMI) was calculated using the Quetelet formula as the ratio of body weight in kilograms to height in meters squared. All patients were classified as obese (BMI ≥ 30 kg / m^2) and non-obese (BMI < 30 kg/m^2).

BP was measured using an automatic tonometer "Omron" (Japan) on the right hand twice with an interval of 2 minutes after 5 minutes of sitting rest. The group of patients with hypertension included individuals with BP level of ≥ 140/90 mm Hg, as well as those taking antihypertensive therapy.

Fasting glucose level, lipid spectrum (total cholesterol — TC, low — density lipoproteins — LDL, high — density lipoproteins-HDL, triglycerides-TG) were also examined (AbbotArchitect 8000 (USA)). All patients were divided into groups by fasting glucose level: normoglycemia (< 5.6 mmol/l), fasting hyperglycemia (glucose level ≥ 5.6 mmol/l, but ≤ 6.9 mmol/l) and with diabetes mellitus (DM) (≥ 7.0 mmol/l and/or receiving treatment with hypoglycemic drugs). Groups of individuals with elevated LDL (> 3.0 mmol/l), triglycerides (≥ 1.7 mmol/l), and low HDL (in men < 1.0 and women < 1.2 mmol/l) were also formed; the use of lipid-lowering therapy was taken into account when dividing patients into groups.

Out of 1,600 participants, 524 subjects were randomly selected to evaluate the pulse wave velocity (PWV) using applanation tonometry by SphygmoCor (AtCor, Australia). The carotid-femoral distance was measured according to the formula recommended by the consensus of vascular stiffness experts in 2012 [6]: (distance from the common carotid artery to the common femoral artery, cm) × 0.8. ECG electrodes were applied to the chest using a standard method, after which pulse waves were recorded with a special sensor using the applanation method for 10 seconds — first in the projection of the common carotid artery on the left, then — the common femoral artery on the left. Taking into account the entered distance and time of the pulse wave passage, the PWV was automatically calculated.

39 patients with associated clinical conditions (coronary heart disease, myocardial infarction and a history of stroke) were excluded from the study. Thus, the results of 485 people (217 men and 268 women) were suitable for analysis. Assessment of the PWV values were adjusted for age, subjects were divided into 5 groups: persons under 30 years, 30–39 years, 40–49 years, 50–59 years 60 years and older. As reference range for the PWV data was taken from "The Reference Values for Arterial Stiffness' Collaboration", which were obtained during a large European study [7]. Criteria of SUPERNOVA phenomenon in each age group was taken to be PWV value equal to or less than 10 percentiles of PWV for healthy individuals (table 1).

Table 1

REFERENCE RANGE OF PWV IN EACH AGE GROUP

Age category (years)	Median (10–90 percentile)
< 30	6.1 (5.3–7.1)
30–39	6.4 (5.2–8.0)
40–49	6.9 (5.9–8.6)
50–59	8.1 (6.3–10.0)
60–69	9.7 (7.9–13.1)
≥ 70	10.6 (8.0–14.6)

Statistical analysis of data was implemented using the IBM SPSS Statistics 20.0 program. Quantitative indicators were evaluated for compliance on the basis of distribution characteristics using the Kolmogorov-Smirnov criteria. Quantitative indicators that have normal distribution, data obtained was combined into variational series, in which arithmetic mean values (M) and standard deviations (SD) were calculated. Aggregates of quantitative indicators distribution of which was different from normal were presented using the values of the median (Me) and the lower and upper quartiles (Q1-Q3). Nominal data were described with absolute values and percentages. In order to compare the average values in normally distributed sets of quantitative data, Student's t-test was calculated. The Mann-Whitney U-test was used to compare independent aggregates in cases where there were no signs of normal data distribution. The nominal data was compared using Pearson's chi-squared test ($\chi 2$). Differences in indicators were considered statistically significant with p-value < 0.05.

Results

The prevalence of SUPERNOVA was 9.8% (48 people). Table 2 shows characteristics of studied population depending on the presence of SUPERNOVA.

In individuals with SUPERNOVA significantly lower levels of SBP and DBP, BMI, glucose, triglycerides and a lower prevalence of hypertension, obesity, hypercholesterolemia and hypertriglyceridemia were detected. The prevalence of SUPERNOVA among men was 7.4% and among women 11.9% (p = 0.52). Table 3 shows characteristics of participants with SUPERNOVA with gender-specific characteristics. According to presented data, women have significantly lower SBP levels and the prevalence of obesity (according to BMI).

Table 2

GENERAL DESCRIPTION OF THE SAMPLE

Parameter	All (n = 485)	The participants with SUPERNOVA (n = 48)	Other participants (n = 437)	p
Age, years	45 [35.0; 53.0]	47.5 [30.5; 58.7]	44 [36.0; 52.0]	0.28
BMI, kg/m²	26.7 [23.2; 30.3]	23.5 [21.1; 26.6]	27.0 [23.7; 30.5]	**< 0.001**
BMI ≥ 30 kg/м², n (%)	156 (32.2%)	8 (16.7%)	148 (33.9%)	**0.015**
Women waist circumference ≥ 80 cm, men waist circumference ≥ 94 cm, n (%)	259 (53.4%)	16 (34.0%)	243 (56.6%)	**0.003**
SBP, mm Hg.	126.5 [115.5; 139.5]	118.5 [110.2; 130.2]	127.5 [117.0; 140.0]	**0.004**
DBP, mm Hg.	78.0 [70.5; 85.5]	73.0 [67.1; 81.0]	78.0 [70.5; 86.0]	**0.008**
Hypertension, n (%)	175 (36.1%)	8 (16.7%)	167 (38.2%)	**0.003**
Total cholesterol, mmol/L	5.3 [4.7; 6.1]	5.0 [4.5; 6.3]	5.3 [4.8; 6.1]	0.22
Total cholesterol > 4,9 mmol/L *, n (%)	332 (68.5%)	27 (56.3%)	305 (70.4%)	**0.04**
LDL, mmol/L	3.4 [2.9; 4.2]	3.2 [2.6; 4.0]	3.4 [2.9; 4.2]	0.12
LDL > 3,0 mmol/L *, n (%)	343 (70.7%)	30 (62.5%)	313 (72.5%)	0.15
HDL in Men <1,0, in Women < 1,2 mmol/L *, n (%)	112 (23.1%)	7 (14.6%)	105 (24.1%)	0.14
Triglycerides, mmol/L	1.04 [0.77; 1.52]	0.90 [0.68; 1.27]	1.09 [0.78; 1.59]	**0.02**
Triglycerides > 1,7 mmol/L *, n (%)	101 (20.8%)	5 (10.4%)	96 (22.5%)	**0.052**
Glucose, mmol/L	5.2 [4.9; 5.6]	5.0 [4.4; 5.6]	5,3 [4,9; 5.6]	**< 0.001**
Fasting hyperglycemia ≥ 5,6 mmol/L, n (%)	126 (26.0%)	7 (14.6%)	119 (27.3%)	0.06
Diabetes, n (%)	13 (2.7%)	1 (2.1%)	12 (2.7%)	0.44
Current smoking, n (%)	121 (24.9%)	12 (25.0%)	109 (24.9%)	1.0
Ex-smoking, n (%)	132 (27.2%)	13 (27.1%)	119 (27.2%)	1.0

Note: p — significance, n — number, BMI — body mass index, SBP — systolic blood pressure, DBP — diastolic blood pressure, LDL — low density lipoprotein, HDL — high-density lipoproteins. * — presence of lipid-lowering therapy. significance, n — number, BMI — body mass index, SBP — systolic blood pressure, DBP — diastolic blood pressure, LDL — low density lipoprotein, HDL — high-density lipoproteins. * — presence of lipid-lowering therapy.

Table 3

THE CHARACTERISTICS OF PARTICIPANTS WITH SUPERNOVA WITH GENDER-SPECIFIC CHARACTERISTICS

Parameter	All (n = 48)	SUPERNOVA Men (n = 16)	SUPERNOVA Women (n = 32)	p
Age, years	47.5 [30.5; 58.7]	39.5 [30.0; 60.5]	51.5 [30.5; 57.5]	0.70
BMI, kg/m²	23.5 [21.1; 26.6]	23.0 [22.0; 29.5]	23.7 [20.9; 26.2]	0.63
BMI≥30 kg/м², n (%)	8 (16.7%)	5 (31.3%)	3 (9.4%)	**0.055**
Women waist circumference ≥ 80 cm, Men waist circumference ≥ 94 cm, n (%)	16 (34.0%)	5 (31.3%)	11 (35.5%)	0.77
SBP, mm Hg.	118.5 [110.2; 130.2]	128.0 [119.0; 145.0]	115.2 [109.2; 123.6]	**0.01**
DBP, mm Hg.	73.0 [67.1; 81.0]	77.2 [69.4; 86.2]	72.5 [63.6; 78.5]	0.08
Hypertension, n (%)	8 (16.7%)	4 (25.0%)	4 (12.5%)	0.27
Total cholesterol, mmol/L	5.0 [4.5; 6.3]	4.7 [4.4; 5.3]	5.2 [4.6; 6.6]	0.18
Total cholesterol > 4,9 mmol/L *, n (%)	27 (56.3%)	6 (37.5%)	21 (65.6%)	0.06
LDL, mmol/L	3.2 [2.6; 4.0]	3.0 [2.5; 3.4]	3.3 [2.6; 4.4]	0.29
LDL > 3,0 mmol/L *, n (%)	30 (62.5%)	10 (62.5%)	20 (62.5%)	1.0
HDL in Men < 1,0, in Women < 1,2 mmol/L *, n (%)	7 (14.6%)	1 (6.3%)	6 (18.8%)	0.25
Triglycerides, mmol/L	0.90 [0.68; 1.27]	0.82 [0.67; 1.22]	0.91 [0.68; 1.29]	0.76
Triglycerides > 1,7 mmol/L *, n (%)	5 (10.4%)	3 (18.8%)	2 (6.3%)	0.18
Glucose, mmol/L	5.0 [4.4; 5.6]	4.9 [4.7; 5.3]	4.8 [4.5; 5.4]	0.56
Fasting hyperglycemia ≥ 5,6 mmol/L, n (%)	7 (14.6%)	2 (12.5%)	5 (15.6%)	0.77
Diabetes, n (%)	1 (2.1%)	1 (6.3%)	0 (0%)	0.29
Current smoking, n (%)	12 (25.0%)	6 (37.5%)	6 (18.8%)	0.22
Ex-smoking, n (%)	13 (27.1%)	5 (31.3%)	8 (25.0%)	0.22

Note: p — significance, n — number, BMI — body mass index, SBP — systolic blood pressure, DBP — diastolic blood pressure, LDL — low density lipoprotein, HDL — high-density lipoproteins. * — presence of lipid-lowering therapy.

Taking into account that age is an important factor for increasing of arterial stiffness comparative analysis was performed in different age groups. The prevalence of participants with SUPERNOVA in the group under 29 years was 23.9%, in the group from 30 to 39 years — 7.7%, from 40 to 49 years — 4.6%, from 50 to 59 years — 11.7% and among people over 60 years — 37.5%. Table 4 shows the characteristics of participants with the SUPERNOVA phenomenon, taking into account age.

Table 4

AGE-BASED CHARACTERISTICS OF PARTICIPANTS WITH SUPERNOVA

Parameter	≤ 29 years old (n = 11)	30–39 years (n = 8)	40–49 years (n = 6)	50–59 years (n = 13)	≥ 60 years (n = 10)
Age, years	27.0 [25.0; 29.0]	35.0 [32.2; 37.7]	44.5 [41.7; 46.7]	54.0 [52.5; 57.0]	62.0 [61.0; 63.2]
BMI, kg/m²	21.0 [20.3; 22.7]	23.2 [22.2; 26.6]	23.6 [20.9; 26.4]	24.9 [22.1; 27.4]	24.7 [22.7; 30.3]
BMI ≥ 30 kg/м², n (%)	1 (9.1%)	1 (12.5%)	1 (16.7%)	2 (15.4%)	3 (30.0%)
Women waist circumference ≥ 80 cm, Men waist circumference ≥ 94 cm, n (%)	2 (18.2%)	1 (12.5%)	1 (20.0%)	7 (53.8%)	5 (50.0%)
SBP, mm Hg.	114.5 [113.5; 129.0]	114.5 [107.1; 122.9]	114.7 [97.1; 121.4]	128.0 [109.5; 137.0]	121.5 [115.5; 140.2]
DBP, mm Hg.	69.5 [62.5; 75.0]	72.0 [67.1; 79.4]	71.7 [62.0; 78.5]	81.0 [69.0; 86.5]	74.7 [71.4; 80.4]
Hypertension, n (%)	2 (18.2%)	0	0	3 (23.1%)	3 (30.0%)
Total cholesterol, mmol/L	4.3 [4.0; 5.1]	4.8 [4.4; 5.6]	6.1 [4.4; 7.3]	5.6 [4.7; 6.5]	5.2 [4.4; 6.3]
Total cholesterol > 4,9 mmol/L *, n (%)	3 (27.3%)	4 (50.0%)	4 (66.7%)	9 (69.2%)	7 (70.0%)
LDL, mmol/L	2.6 [2.2; 3.1]	3.1 [2.5; 3.6]	4.0 [2.3; 5.3]	3.3 [3.0; 4.2]	3.4 [2.6; 4.6]
LDL > 3,0 mmol/L *, n (%)	4 (36.4%)	4 (50.0%)	4 (66.7%)	10 (76.9%)	8 (80.0%)
HDL in Men < 1,0, in Women < 1,2 mmol/L *, n (%)	1 (9.1%)	2 (25.0%)	1 (16.7%)	1 (7.7%)	2 (20.0%)
Triglycerides, mmol/L	0.71 [0.68; 1.10]	0.85 [0.64; 1.17]	0.78 [0.65; 1.69]	1.05 [0.84; 1.31]	0.96 [0.80; 1.29]
Triglycerides > 1,7 mmol/L *, n (%)	1 (9.1%)	1 (12.5%)	1 (16.7%)	1 (7.7%)	1 (10.0%)
Glucose, mmol/L	4.8 [4.6; 5.3]	4.7 [4.5; 5.0]	5.0 [4.3; 5.7]	4.8 [4.3; 5.4]	5.3 [4.8; 5.6]
Fasting hyperglycemia ≥ 5,6 mmol/L, n (%)	0 (0%)	1 (12.5%)	1 (16.7%)	2 (15.4%)	3 (30.0%)
Diabetes, n (%)	0	0	0	0	1 (10,0%)
Current smoking, n (%)	4 (36,4%)	3 (37.5%)	1 (16.7%)	3 (23.1%)	1 (10.0%)
Ex-smoking, n (%)	3 (27.3%)	2 (25.0%)	2 (33.3%)	4 (30.8%)	2 (20.0%)

Note: p — significance, n — number, BMI — body mass index, SBP — systolic blood pressure, DBP — diastolic blood pressure, LDL — low density lipoprotein, HDL — high-density lipoproteins. * — presence of lipid-lowering therapy.

Table 5

CHARACTERISTICS OF PARTICIPANTS AGED 24-29 YEARS DEPENDING ON THE PRESENCE OF SUPERNOVA

Parameter	SUPERNOVA (n = 11)	No SUPERNOVA (n = 42)	P
Age, years	27.0 [25.0; 29.0]	27.0 [25.0; 29.0]	0,92
BMI, kg/m²	21 [20.3; 22.7]	24.2 [21.0; 27.6]	**0,046**
BMI ≥ 30 kg/м², n (%)	1 (9.1%)	8 (19.0%)	0,43
Women waist circumference ≥ 80 cm, Men waist circumference ≥ 94 cm, n (%)	2 (18.2%)	10 (24.4%)	0,66
SBP, mm Hg.	114.5 [113.5; 129.0]	123.0 [111.7; 134.5]	0,44
DBP, mm Hg.	69.5 [62.5; 75.0]	71.2 [63.9; 75.0]	0.68
Hypertension, n (%)	2 (18.2%)	6 (14.3%)	0.75
Total cholesterol, mmol/L	4.3 [4.0; 5.1]	4.6 [4,0; 5.3]	0.46
Total cholesterol > 4,9 mmol/L *, n (%)	3 (27.3%)	16 (38.1%)	0.50
LDL, mmol/L	2.6 [2.2; 3.1]	2.7 [2.2; 3.4]	0,70
LDL > 3,0 mmol/L *, n (%)	4 (36.4%)	17 (40.5%)	0.80
HDL in Men <1,0, in Women <1,2 mmol/L *, n (%)	1 (9.1%)	5 (11.9%)	0.79
Triglycerides, mmol/L	0.71 [0.68; 1.10]	0.73 [0.56; 1.04]	0.56
Triglycerides > 1,7 mmol/L *, n (%)	1 (9.1%)	2 (4.8%)	0.58
Glucose, mmol/L	4.8 [4.6; 5.3]	5.0 [4.8; 5.4]	0.17
Fasting hyperglycemia ≥ 5,6 mmol/L, n (%)	0 (0%)	7 (13.2%)	0.15
Diabetes, n (%)	0	0	–
Current smoking, n (%)	4 (36.4%)	8 (19.1%)	0.42
Ex-smoking, n (%)	3 (27.3%)	11 (26.2%)	0.42

Note: p — significance, n — number, BMI — body mass index, SBP — systolic blood pressure, DBP — diastolic blood pressure, LDL — low density lipoprotein, HDL — high-density lipoproteins. * — presence of lipid-lowering therapy.

Individuals with SUPERNOVA, regardless of age, have low prevalence of diabetes (participants under 60 years did not suffer from diabetes at all) and fasting hyperglycemia. Participants over 50 years had higher BP levels compared to younger individuals, as well as the prevalence of hypertension and abdominal obesity.

Table 5 shows the results of comparing subjects aged 24–29 years depending on the presence of SUPERNOVA.

In the group under 30 years, only the prevalence of obesity according to the BMI was significantly lower in respondents with SUPERNOVA comparing with non-SUPERNOVA participants.

Table 6 shows the results of comparing patients with age from 30 to 39 years depending on the presence of SUPERNOVA.

Among participants with aged 30–39 years with SUPERNOVA, the prevalence of abdominal obesity was lower, and the significance of normotension (lower BP and no hypertension) becomes of importance, although these differences are not statistically significant comparing with non-SUPERNOVA participants.

Table 6

CHARACTERISTICS OF PARTICIPANTS AGED 30-39 YEARS DEPENDING ON THE PRESENCE OF SUPERNOVA

Parameter	SUPERNOVA (n = 8)	No SUPERNOVA (n = 119)	p
Age, years	35.0 [32.2; 37.7]	35.0 [32.0; 37.0]	0.92
BMI, kg/m²	23.2 [22.2; 26.6]	25.0 [22.3; 29.3]	0.29
BMI ≥ 30 kg/м², n (%)	1 (12.5%)	31 (26.1%)	0.39
Women waist circumference ≥ 80 cm, Men waist circumference ≥ 94 cm, n (%)	1 (12.5%)	55 (47.0%)	0.06
SBP, mm Hg.	114.5 [107.1; 122.9]	122.5 [112.5; 134.0]	0.17
DBP, mm Hg.	72.0 [67.1; 79.4]	74.0 [68.5; 84.0]	0.56
Hypertension, n (%)	0	29 (24.4%)	0.11
Total cholesterol, mmol/L	4.8 [4.4; 5.6]	5.1 [4.6; 5.8]	0.48
Total cholesterol > 4,9 mmol/L *, n (%)	4 (50.0%)	72 (62.1%)	0.50
LDL, mmol/L	3.1 [2.5; 3.6]	3.2 [2.8; 4.0]	0.63
LDL > 3,0 mmol/L *, n (%)	4 (50.0%)	74 (64.3%)	0.41
HDL in Men < 1,0, in Women < 1,2 mmol/L *, n (%)	2 (25.0%)	34 (29.1%)	0.81
Triglycerides, mmol/L	0.85 [0.64; 1.17]	0.94 [0.67; 1.48]	0.57
Triglycerides > 1,7 mmol/L *, n (%)	1 (12.5%)	23 (20.4%)	0.59
Glucose, mmol/L	4,7 [4.5; 5.0]	5.0 [4.7; 5.5]	0.18
Fasting hyperglycemia ≥ 5,6 mmol/L, n (%)	1 (12.5%)	22 (18.6%)	0.66
Diabetes, n (%)	0	2 (1.7%)	0.91
Current smoking, n (%)	3 (37.5%)	33 (27.7%)	0.84
Ex-smoking, n (%)	2 (25.0%)	34 (28.6%)	0.84

Note: p — significance, n — number, BMI — body mass index, SBP — systolic blood pressure, DBP — diastolic blood pressure, LDL — low density lipoprotein, HDL — high-density lipoproteins. * — presence of lipid-lowering therapy.

Table 7 shows the results of comparing patients with agre from 40 to 49 years depending on the presence of SUPERNOVA.

In the group of SUPERNOVA participants aged 40–49 years significantly lower BMI level and the prevalence of abdominal obesity were detected. In this group the levels of SBP and DBP were also significantly lower, but the differences in the prevalence of hypertension was not statistically significant comparing with non-SUPERNOVA participants.

Table 8 shows the results of comparing individuals with age from 50 to 59 years depending on the presence of SUPERNOVA.

The lower prevalence of hypertension in patients with SUPERNOVA becomes statistically significant only in patients over the age of 50 years. Significantly

Table 7

CHARACTERISTICS OF PARTICIPANTS AGED 40–49 YEARS DEPENDING ON THE PRESENCE OF SUPERNOVA

Parameter	SUPERNOVA (n = 6)	No SUPERNOVA (n = 129)	p
Age, years	44.5 [41.7; 46.7]	45.0 [42.0; 47.0]	0.81
BMI, kg/m²	23.6 [20.9; 26.4]	27.6 [24.8; 32.4]	**0.02**
BMI ≥ 30 kg/м², n (%)	1 (16.7%)	53 (41.1%)	0.23
Women waist circumference ≥ 80 cm, Men waist circumference ≥ 94 cm, n (%)	1 (20.0%)	80 (65.3%)	**0.05**
SBP, mm Hg.	114.7 [97.1; 121.4]	125.5 [115.0; 138.2]	**0.03**
DBP, mm Hg.	71.7 [62.0; 78.5]	80.0 [71.7; 87.2]	**0.048**
Hypertension, n (%)	0	48 (37.2%)	0.06
Total cholesterol, mmol/L	6.1 [4.4; 7.3]	5.4 [4.9; 6.0]	0.40
Total cholesterol > 4,9 mmol/L *, n (%)	4 (66.7%)	99 (77.3%)	0.54
LDL, mmol/L	4.0 [2.3; 5.3]	3.5 [2.9; 4.1]	0.65
LDL > 3,0 mmol/L *, n (%)	4 (66.7%)	96 (75.0%)	0.65
HDL in Men < 1,0, in Women < 1,2 mmol/L *, n (%)	1 (16.7%)	30 (23.3%)	0.71
Triglycerides, mmol/L	0.78 [0.65; 1.69]	1.19 [0.85; 1.65]	0.21
Triglycerides >1,7 mmol/L *, n (%)	1 (16.7%)	30 (23.3%)	0.71
Glucose, mmol/L	5.0 [4.3; 5.7]	5.3 [5.0;5.7]	0.23
Fasting hyperglycemia ≥ 5,6 mmol/L, n (%)	1 (16.7%)	35 (27.1%)	0.57
Diabetes, n (%)	0	3 (2.2%)	0.86
Current smoking, n (%)	1 (16.7%)	32 (24.8%)	0.89
Ex-smoking, n (%)	2 (33.3%)	36 (27.9%)	0.89

Note: p — significance, n — number, BMI — body mass index, SBP — systolic blood pressure, DBP — diastolic blood pressure, LDL — low density lipoprotein, HDL — high-density lipoproteins. * — presence of lipid-lowering therapy.

lower BMI and glucose levels were found comparing with non-SUPERNOVA participants.

Table 9 shows the results of comparing participants aged 60–65 years depending on the presence of SUPERNOVA.

In subjects of the older age group with SUPERNOVA levels of SBP and DBP were significantly lower and hypertension was less common comparing with non-SUPERNOVA participants.

Discussion

Our study shows approximately 10% prevalence of SUPERNOVA in a group of 485 residents of St. Petersburg without cardiovascular complications aged 24–65 years, whose vascular aging was assessed by evaluating arterial stiffness. Arterial stiffness is the best indicator of the combined effect of known and unknown risk factors for arterial wall damage [1]. Studies suggest that subjects with the SUPERNOVA are protected from exposure to risk factors of cardiovascular diseases, de-

Table 8

CHARACTERISTICS OF PARTICIPANTS AGED 50-59 YEARS DEPENDING ON THE PRESENCE OF SUPERNOVA

Parameter	SUPERNOVA (n=13)	No SUPERNOVA (n=129)	p
Age, years	54.0 [52.5; 57.0]	53.0 [52.0; 56.0]	0.16
BMI, kg/m²	24.9 [22.1; 27.4]	27.6 [24,3; 30.8]	**0.04**
BMI ≥ 30 kg/м², n (%)	2 (15.4%)	49 (38.0%)	0.10
Women waist circumference ≥ 80 cm, Men waist circumference ≥ 94 cm, n (%)	7 (53.8%)	84 (66.1%)	0.38
SBP, mm Hg.	128.0 [109.5; 137.0]	134.0 [122.2; 144.2]	0.11
DBP, mm Hg.	81.0 [69.0; 86.5]	81.5 [75.0; 87.7]	0.32
Hypertension, n (%)	3 (23.1%)	71 (55.0%)	**0.03**
Total cholesterol, mmol/L	5.6 [4.7; 6.5]	5.8 [5,1; 6.6]	0.76
Total cholesterol > 4,9 mmol/L *, n (%)	9 (69.2%)	102 (79.1%)	0.41
LDL, mmol/L	3.3 [3.0; 4.2]	3.9 [3.2; 4.5]	0.26
LDL > 3,0 mmol/L *, n (%)	10 (76.9%)	110 (85.3%)	0.43
HDL in Men < 1,0, in Women < 1,2 mmol/L *, n (%)	1 (7.7%)	35 (27.1%)	0.12
Triglycerides, mmol/L	1.05 [0.84; 1.31]	1.24 [0.92; 1.71]	0.18
Triglycerides > 1,7 mmol/L *, n (%)	1 (7.7%)	36 (29.0%)	0.099
Glucose, mmol/L	4.8 [4.3; 5.4]	5.4 [5.0; 5.8]	**0.005**
Fasting hyperglycemia ≥ 5,6 mmol/L, n (%)	2 (15.4%)	47 (36.4%)	0.13
Diabetes, n (%)	0 (0%)	7 (5.4%)	0.33
Current smoking, n (%)	3 (23.1%)	35 (27.1%)	0.92
Ex-smoking, n (%)	4 (30.8%)	34 (26.4%)	0.92

Note: p — significance, n — number, BMI — body mass index, SBP — systolic blood pressure, DBP — diastolic blood pressure, LDL — low density lipoprotein, HDL — high-density lipoproteins. * — presence of lipid-lowering therapy.

spite their negative effects. According to the concept of protective mechanisms leading to SUPERNOVA it is likely that those individuals may only have a fraction of the known risk factors and they are protected (or less sensitive) from the harmful effects of other risk factors of cardiovascular diseases. It remains an open question whether the consideration of cardiovascular risk factors should be extensive or not in order to identify SUPERNOVA individuals in population. Some risk factors are easily detected (age, gender, BP, smoking), and some factors are well-known but they are difficult to quantify (heredity, perceived stress, social and economical factors), to assess the timing of exposure and mostly remain unknown [4].

In our study, the evaluated factors associated with the supernormal vascular aging were normal BP, normal body weight, lower blood glucose levels and an optimal lipid panel levels. Stratification of the sample

into age groups allowed us to identify age-related features of the influence of risk factors. Younger patients with SUPERNOVA had a lower BMI, but other common risk factors did not have a significant effect. It is possible that the cumulative effect of influence of those common risk factors is only apparent in older age. Lower BP rates in the presence of the SUPERNOVA were registered from the age of 30, but they are statistically significant only after 50 years. Only in the group aged over 40 years lower prevalence of abdominal obesity becomes statistically significant and in the group aged 50 years — glucose level. It is worth noting that in all age groups there was a tendency to lower triglyceride levels in the presence of the SUPERNOVA with no statistical significance. When discussing the mechanisms of "healthy" (normal) aging German researchers noted that up to 50 years most individuals have similar indicators of arterial stiffness and only in older age, het-

Table 9

CHARACTERISTICS OF PARTICIPANTS AGED 60-65 YEARS DEPENDING ON THE PRESENCE OF SUPERNOVA

Parameter	SUPERNOVA (n=10)	No SUPERNOVA (n=18)	P
Age, years	62.0 [61.0; 63.2]	61.0 [61.0; 63.0]	0.33
BMI, kg/m²	24.7 [22.7; 30.3]	28.7 [26.2; 31.4]	0.057
BMI ≥ 30 kg/м², n (%)	3 (30.0%)	7 (38.9%)	0.64
Women waist circumference ≥80 cm, Men waist circumference ≥ 94 cm, n (%)	5 (50.0%)	14 (77.8%)	0.13
SBP, mm Hg.	121.5 [115.5; 140.2]	146.2 [128.4; 156.7]	**0.014**
DBP, mm Hg.	74.7 [71.4; 80.4]	86.2 [77.9; 95.1]	**0.014**
Hypertension, n (%)	3 (30.0%)	13 (72.2%)	**0.03**
Total cholesterol, mmol/L	5.2 [4.4; 6.3]	6.6 [5.3; 7.2]	0.072
Total cholesterol > 4,9 mmol/L *, n (%)	7 (70.0%)	16 (88.9%)	0.21
LDL, mmol/L	3.4 [2.6; 4.6]	4.5 [3.3; 5.1]	0.16
LDL > 3,0 mmol/L *, n (%)	8 (80.0%)	16 (88.9%)	0.52
HDL in Men < 1,0, in Women < 1,2 mmol/L *, n (%)	2 (20.0%)	1 (5.6%)	0.24
Triglycerides, mmol/L	0.96 [0.80; 1.29]	1.20 [0.91; 1.82]	0.13
Triglycerides > 1,7 mmol/L *, n (%)	1 (10.0%)	5 (27.8%)	0.27
Glucose, mmol/L	5.3 [4.8; 5.6]	5.6 [5.2; 5.8]	0.13
Fasting hyperglycemia 5,6 ≥ mmol/L, n (%)	3 (30.0%)	8 (44.4%)	0.45
Diabetes, n (%)	1 (10.0%)	0	0.39
Current smoking, n (%)	1 (10.0%)	1 (5.6%)	0.91
Ex-smoking, n (%)	2 (20.0%)	4 (22.2%)	0.91

Note: p — significance, n — number, BMI — body mass index, SBP — systolic blood pressure, DBP — diastolic blood pressure, LDL — low density lipoprotein, HDL — high-density lipoproteins. * — presence of lipid-lowering therapy.

erogeneity is registered according to the accumulated "life baggage" of risk factors [8].

The study of risk factors of cardiovascular diseases in young people in Finland [9] showed that metabolic syndrome in childhood and adolescence (age 9–18 years) predicts the level of arterial stiffness in adulthood (PWV measurements were performed 21 years later at the age of 30–39 years). In addition, restoring of metabolic status in children was associated with decreased arterial rigidity at an older age. Hypertension is one of the main determinants of vascular stiffness but on the other hand, a long-term increase in vascular wall rigidity predicts the occurrence of hypertension. The research group of the same authors from Finland demonstrated that increased arterial stiffness in a cohort aged 30–49 years is a predictor of risk of developing hypertension in 4 years [10]. Increased arterial stiffness significantly contributes to the pathophysiology of age-related extensions in the burden of cardiovascular diseases, such as congestive heart failure, isolated systolic hypertension, and orthostatic hypotension [11].

It is worth noting that according to our results, lower BMI scores in the older age group were associated with better health of blood vessel wall, although those were higher compared to SUPERNOVA individuals in other age groups. Perhaps this feature in the older age group is related to the age-dependent process of reducing muscle tissue and insufficient physical activity. A number of studies showed that middle-aged and elderly people who regularly perform endurance training show lower arterial stiffness compared to age-comparable hypodynamic individuals [11]. Higher physical activity in old age is associated with lower arterial stiffness and pulse pressure. More importantly, associations were stronger when the analysis was limited to participants with consistent levels of physical activity. These results obtained in US communities were consistent with studies conducted in the European community showing that moderate to active physical activity was associated with slower age-related changes of central arteries stiffness [12].

In our study, the prevalence of the SUPERNOVA did not significantly differ between men and women. The analysis of the profile of common risk factors revealed a lower level of SBP and the prevalence of obesity in women. Thus, women need to monitor their body weight and BP more carefully to keep their blood vessels in perfect condition. Earlier studies on gender differences indicated that women are characterized by higher arterial stiffness with a subsequent increase in load on the left ventricle and an increase in the risk of developing heart failure with a preserved ejection fraction [14].

The results showed that exposure to known risk factors (hypertension, obesity, metabolic disorders) can slow down vascular aging and prevent cardiovascular complications.

Conflict of interest / Конфликт интересов
The authors declare no conflict of interest. / Авторы заявили об отсутствии конфликта интересов.

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