doi:10.15829/1728-8800-2020-S1

Prevalence of hypotension in populations of the Russian Federation and the United States of America according to 30-year follow-up

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Aim. To study the prevalence of hypotension according to several criteria in the Russia and the USA.

Material and methods. We used data of Russian population studies performed in 1975-1982 and ESSE-RF study performed in 2012-2014 at the National Medical Research Center for Therapy and Preventive Medicine. A comparison was made with the data of cross-sectional studies of the US population — National Health and Nutrition Examination Survey (NHANES): NHANES II (1976-1980) and Continuous NHANES (2007-2012). We analyzed age, sex, and systolic and diastolic blood pressure. The prevalence of individuals with hypotension was calculated in men and women of five age groups using four different criteria for hypertension.

Results. The prevalence of hypotension in studies of different years according to different criteria was as follows: in the Russia — 0,3-9,0% in men and 2-15% in women; in the USA — 5-30% in men and 8-45% in women. In age group >30 years, the prevalence of hypotension in Russia, by most criteria, decreased approximately by 50% in men and did not change in women. In the United States, according to all criteria, the prevalence in men and women has increased 2-3 times.

Conclusion. The prevalence of hypotension in the adult population ranges from decimal percentages to 45% and varies many times depending on the selected criterion.

Key words: hypotension, prevalence, population, Russia, USA, epidemiological study.

Relationships and Activities. The ESSE-RF study was performed as part of a state assignment № AAAA-A20-120013090086-0.

Acknowledgements. This study was made possible through free access to NHANES research data provided by the National Center for Health Statistics (USA). Authors of the article are responsible for the results of analysis, interpretation and conclusions. The National Center for Health Statistics is responsible only for primary data.

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Received: 04/03-2020
Revision Received: 06/04-2020
Accepted: 10/04-2020

For citation: Vilkov V. G., Shalnova S. A., Balanova Yu. A., Evstifeeva S. E., Imaeva A. E., Kapustina A. V., Muromtseva G. A. Prevalence of hypotension in populations of the Russian Federation and the United States of America according to 30-year follow-up. *Cardiovascular Therapy and Prevention*. 2020;19(3):2497. (In Russ.) doi:10.15829/1728-8800-2020-2497

Introduction

Clinical description of hypotension (HoTN) appeared in the late 19th and early 20th centuries. The Italian scientist Andrea Ferranini is considered to be the founder of HoTN study [1]. The main manifestation of HoTN is an excessive decrease in blood pressure (BP) >20% of the norm.

HoTN is called a forgotten illness [2]. This is due to the fact that with the accumulation of information about the role of hypertension (HTN) as the most important risk factor for cardiovascular diseases and one of the leading causes of death and disability in developed countries, HTN has attracted more and more attention of researchers and health professionals. Therefore, HoTN is in the shadow of HTN [3].

According to the International Classification of Diseases, Tenth Revision (ICD-10), there are following diseases: idiopathic hypotension (I95.0); orthostatic hypotension (I95.1); Hypotension due to drugs (I95.2); other hypotension (I95.8); unspecified hypotension (I95.9). Obviously, in the part of the listed disorders, HoTN is secondary, and represents a symptom of other diseases. As already mentioned, much less attention is paid to the problem of HoTN in comparison with HTN. There is an opinion that low BP is not associated with increased cardiovascular mortality. Therefore, HoTN is regarded as a nondisease [4]. However, according to some population-based prospective studies, the dependence of mortality on BP is not linear, but J-shaped — with an excessively low BP, mortality is higher in comparison with its optimal level. Although the severity of this effect is significantly lower than the increase in mortality due to HTN [5]. In a Russian cohort study of persons ⩾55 years old adjusted for risk factors, an association of cardiovascular mortality with both high BP and systolic BP (SBP) <120 mm Hg was found [6].

There is no single approach to the diagnosis of HoTN. Some researchers took into account only

Table 1

Prevalence of HoTN according to the HoTN-1 criterion

Sex and age (years)	Population											
	RF-80			NHANES2			ESSE-RF			C.NHANES		
	A/n	ER	P0÷P1	A/n	ER	P0÷P1	A/n	ER	P0÷P1	A/n	ER	P0÷P1
						Men						
18-24	1/312	0,3	0÷1,5	65/843	7,7	6,3÷9,4						
25-34	4/715	0,6	0,2÷1,3	52/901	5,8	4,6÷7,2	50/2049	2,4	1,9÷3,1	74/475	15,6	12,9÷18,6
35-44	14/2885	0,5	0,3÷0,8	14/651	2,2	1,3÷3,3	18/1686	1,1	0,7÷1,6	37/486	7,6	5,7÷9,9
45-54	15/5246	0,3	0,2÷0,4	9/617	1,5	0,8÷2,5	20/2049	1,0	0,7÷1,4	41/514	8,0	6,1÷10,2
>54	4/1974	0,2	0,1÷0,5	55/2126	2,6	2,1÷3,2	17/2091	0,8	0,5÷1,2	46/470	9,8	7,6÷12,3
Total	38/11132	0,3	0,2÷0,5	195/5138	3,8	3,4÷4,3	105/7875	1,3	1,1÷1,6	198/1945	10,2	9,1÷11,4
						Women						
18-24	23/144	16,0	11,2÷21,9	182/890	20,4	18,2÷22,8						
25-34	72/932	7,7	6,3÷9,3	157/994	15,8	13,9÷17,8	201/2330	8,6	7,7÷9,6	121/473	25,6	22,3÷29,1
35-44	32/1431	2,2	1,6÷3,0	56/721	7,8	6,2÷9,6	84/2507	3,4	2,8÷4,0	105/556	18,9	16,2÷21,8
45-54	6/1390	0,4	0,2÷0,9	25/644	3,9	2,7÷5,4	80/3837	2,1	1,7÷2,5	64/529	12,1	9,8÷14,7
>54	5/1847	0,3	0,1÷0,6	83/2411	3,4	2,9÷4,1	58/4467	1,3	1,0÷1,6	70/469	14,9	12,3÷17,9
Total	138/5744	2,4	2,1÷2,8	503/5660	8,9	8,3÷9,5	423/13141	3,2	3,0÷3,5	360/2027	17,8	16,4÷19,2

Note: RF-80 — Russian population studies conducted in 1975-1982; ESSE-RF — study conducted in 2012-2014; A — number of persons with HoTN; C.NHANES — Continuous NHANES study conducted in 2007-2012; ER — proportion of persons with HoTN; NHANES2 — NHANES II study conducted in 1976-1980; n — total number of subjects in the group; P0÷P1 — prevalence confidence interval for p=0,95.

the BP level, but a more common point of view is that, in addition to BP, it is necessary to distinguish physiological and pathological HoTN and take into account clinical manifestations of insufficient blood supply to organs [1].

The diagnostically significant BP values proposed by different researchers differ. For example, according to numerous researchers (meta-analysis for 1914-1955), the limits of hypotension for SBP varied from 120 to 90 mm Hg and for diastolic BP (DBP) from 70 to 40 mm Hg [1]. Some authors recommend the distribution of BP values based on a specific sample [7].

The aim was to study the prevalence of HoTN according to several criteria in the Russia and the USA.

Material and methods

The work used data from Russian population-based studies performed in 1975-1982 and ESSE-RF study performed in 2012-2014 at the National Medical Research Center for Therapy and Preventive Medicine [8, 9]. The study was approved by the ethics committee of the National Medical Research Center for Preventive Medicine. All patient signed informed consent.

A comparison was made with the data of cross-sectional studies of the US population — National Health and Nutrition Examination Survey (NHANES): NHANES II (1976-1980) and Continuous NHANES (2007-2012). The design of these is described in the original documents [10]. The studies included only white people.

The age, sex, SBP and DBP values measured on the brachial artery were analyzed. The Russian studies took into account the data on the history of HTN and the use of antihypertensive agents.

The prevalence of HoTN was calculated in men and women in the following age groups: 18-24, 25-34, 35-44, 45-54, ⩾55 years. Due to the absence of a generally accepted criterion for HoTN, the prevalence of HoTN was studied according to several criteria:

- HoTN-1 — single criterion for men and women, regardless of age, with a SBP/DBP level of ⩽90/60 mm Hg [11];
- HoTN-2 — persons ⩽25 years old — SBP <100 or DBP <60 mm Hg; persons >25 years — SBP <105 or DBP <60 mm Hg, regardless of sex [1];
- HoTN-3 — persons ⩽35 years old — SBP ⩽100 or DBP ⩽60 mm Hg; persons 36-54 years old — SBP ⩽110 or DBP ⩽70 mm Hg; persons ⩾55 years old — SBP ⩽120 or DBP ⩽70 mm Hg, regardless of sex [12];
- HoTN-4 — criteria for men — SBP <110 or DBP <60 mm Hg; for women — SBP <100 or DBP <60 mm Hg, regardless of age [13].

Data on the prevalence of HoTN in age and sex groups for each of the listed criteria are shown in Tables 1-4.

For statistical analysis, standard statistical procedures were used. The proportion of persons with HoTN was calculated according to the corresponding criterion and its confidence interval (P0÷P1) [14], which allows to estimate the HoTN prevalence in the general population with a confidence coefficient of 0,95 and compare it in different samples.

Results and discussion

According to the HoTN-1 criterion [11], the prevalence of HoTN in the modern Russian population (2012-2014ESSE-RF) is 1,3% in men and 3,2% in women, and in the US population (2007-2012 Continuous NHANES) — 10,2% and 17,8%, respectively. In both populations, in men 25-34 years old, the frequency of HoTN is significantly higher than in older age groups. In women, the prevalence of HoTN naturally decreases with an increase in age from 25 to 54 years (Table 1).

Table 2

Prevalence of HoTN according to the HoTN-2 criterion

Sex and age (years)	Population											
	RF-80			NHANES2			ESSE-RF			C.NHACNES		
	A/n	ER	P0÷P1	A/n	ER	P0÷P1	A/n	ER	P0÷P1	A/n	ER	P0÷P1
Men												
18-24	2/312	0,6	0,1÷2,0	45/843	5,3	4,1÷6,8						
25-34	31/715	4,3	3,2÷5,8	85/901	9,4	7,9÷11,2	62/2049	3,0	2,4÷3,7	85/475	17,9	15,1÷21,0
35-44	131/2885	4,5	3,9÷5,2	38/651	5,8	4,4÷7,6	32/1686	1,9	1,4÷2,5	60/486	12,3	10,0÷15,1
45-54	142/5246	2,7	2,4÷3,1	30/617	4,9	3,5÷6,5	35/2049	1,7	1,3÷2,3	74/514	14,4	11,9÷17,2
>54	36/1974	1,8	1,4÷2,4	64/2126	3,0	2,4÷3,7	23/2091	1,1	0,8÷1,6	68/470	14,5	11,9÷17,4
Total	342/11132	3,1	2,8÷3,4	262/5138	5,1	4,6÷5,6	152/7875	1,9	1,7÷2,2	287/1945	14,8	13,5÷16,1
Women												
18-24	29/144	20,1	14,8÷26,4	175/890	19,7	17,5÷22,0						
25-34	166/932	17,8	15,8÷20,0	283/994	28,5	26,1÷30,9	393/2330	16,9	15,6÷18,2	207/473	43,8	39,9÷47,7
35-44	119/1431	8,3	7,1÷9,6	133/721	18,4	16,1÷21,0	272/2507	10,9	9,8÷11,9	184/556	33,1	29,8÷36,5
45-54	53/1390	3,8	3,0÷4,8	60/644	9,3	7,5÷11,4	184/3837	4,8	4,2÷5,4	117/529	22,1	19,2÷25,3
>54	16/1847	0,9	0,5÷1,3	96/2411	4,0	3,4÷4,7	87/4467	1,9	1,6÷2,3	90/469	19,2	16,2÷22,4
Total	383/5744	6,7	6,1÷7,2	747/5660	13,2	12,5÷14,0	936/13141	7,1	6,8÷7,5	598/2027	29,5	27,8÷31,2

Note: RF-80 — Russian population studies conducted in 1975-1982; ESSE-RF — study conducted in 2012-2014; A — number of persons with HoTN; C.NHANES — Continuous NHANES study conducted in 2007-2012; ER — proportion of persons with HoTN; NHANES2 — NHANES II study conducted in 1976-1980; n — total number of subjects in the group; P0÷P1 — prevalence confidence interval for p=0,95.

According to this criterion, in the 1980s, the frequency of HoTn in Russian men was ~4 times lower in comparison with ESSE-RF and did not significantly depend on age. In comparison with modern data, the prevalence of HoTN in Russian women was on average slightly lower (significant for age ⩾45 years).

In the US population in the late 1980s, in comparison with the Continuous NHANES study, the incidence of HoTN was significantly lower in all age groups of men and women. In the United States, the prevalence of HoTN has on average increased 3 times in men and 2 times in women over 30 years (Table 1).

Thus, when using the HoTN-1 criterion not taking into account sex and age, a number of regularities were revealed:

• Prevalence of HoTN in women is higher than in men;

• In comparable periods of follow-up, the prevalence of HoTN was higher in the United States compared to the Russian Federation in both men and women (in the 2010s, 5-7 times; in the 1980s, 3-12 times);

• The prevalence of HoTN for 30 years has increased in men and women, both in the Russian Federation and in the United States.

The BP level rises with age, which the basis of the approach of the researchers who proposed the criteria for HoTN adjusted for age [1, 12, 15]. Such criteria can be relatively simple, using fixed BP values in several age ranges [1, 12], or more complex, when the cut-off values are calculated as 102+ age multiplied by 0,6 for SBP; and as 63+ age multiplied by 0,4 for DBP [15].

The prevalence of HoTN was studied according to the N. S. Molchanov criterion. The scientific school founded by him occupied a leading position in HoTN issue in Russia [1]. According to this criterion, HoTN includes persons ⩽25 years old with SBP <100 or DBP <60 mm Hg, and persons >25 years old with SBP <105 or DBP <60 mm Hg, regardless of sex (HoTN-2 criterion). The data on the prevalence of HoTN according to this criterion are presented in Table 2. The results obtained demonstrated a higher incidence of HoTN, which is most likely associated with a greater contribution of SBP. The patterns described above are confirmed, with the exception of the 30-year HoTN prevalence in the Russian Federation: the prevalence of HoTN-2 in men has decreased, and in women, the increase in HoTN prevalence is not as demonstrative as when using the HoTN-1 criterion.

It should be noted that in modern populations of both the Russian Federation and the United States, persons aged 25 and over were examined. Therefore, the N. S. Molchanov criterion is almost independent of age. In the RF-1980 and NHANES II studies, the prevalence of HoTN in persons aged 18-24 was lower than expected, since in young people a higher prevalence was expected. It can be assumed that, as applied to population data, age is not taken into account correctly in the HoTN-2 criterion.

The HoTN-3 criterion, differentiated for three age ranges, was described by J. Yu. Chefranova (2008) [12]. The prevalence of HoTN according to this criterion are presented in Table 3. The higher prevalence of HoTN in women compared with men was revealed. The

Table 3

Prevalence of HoTN according to the HoTN-3 criterion

Sex and age (years)	Population											
	RF-80			NHANES2			ESSE-RF			C.NHANES		
	A/n	ER	P0÷P1	A/n	ER	P0÷P1	A/n	ER	P0÷P1	A/n	ER	P0÷P1
						Men						
18-24	2/312	0,6	0,1÷2,0	45/843	5,3	4,1÷6,8						
25-34	14/715	2,0	1,2÷3,0	30/901	3,3	2,4÷4,5	34/2049	1,7	1,2÷2,2	64/475	13,5	11,0÷16,3
35-44	322/2885	11,2	10,2÷12,2	72/651	11,1	9,1÷13,3	124/1686	7,4	6,3÷8,5	144/486	29,6	26,2÷33,2
45-54	366/5246	7,0	6,4÷7,6	54/617	8,8	7,0÷10,9	113/2049	5,5	4,7÷6,4	156/514	30,4	27,0÷33,9
>54	285/1974	14,4	13,2÷15,8	315/2126	14,8	13,6÷16,1	230/2091	11,0	9,9÷12,2	210/470	44,7	40,8÷48,6
Total	989/11132	8,9	8,4÷9,3	516/5138	10,0	9,4÷10,8	501/7875	6,4	5,9÷6,8	574/1945	29,5	27,8÷31,3
						Women						
18-24	29/144	20,1	14,8÷26,4	175/890	19,7	17,5÷22,0						
25-34	102/932	10,9	9,3÷12,8	147/994	14,8	13,0÷16,8	217/2330	9,3	8,3÷10,4	133/473	28,1	24,7÷31,7
35-44	280/1431	19,6	17,9÷21,4	177/721	24,5	21,9÷27,3	553/2507	22,1	20,7÷23,5	284/556	51,1	47,5÷54,7
45-54	159/1390	11,4	10,1÷12,9	113/644	17,5	15,1÷20,2	518/3837	13,5	12,6÷14,4	243/529	45,9	42,3÷49,6
>54	130/1847	7,0	6,1÷8,1	383/2411	15,9	14,7÷17,2	659/4467	14,8	13,9÷15,7	248/469	52,9	49,0÷56,8
Total	700/5744	12,2	11,5÷12,9	995/5660	17,6	16,8÷18,4	1947/13141	14,8	14,3÷15,3	908/2027	44,8	43,0÷46,6

Note: RF-80 — Russian population studies conducted in 1975-1982; ESSE-RF — study conducted in 2012-2014; A — number of persons with HoTN; C.NHANES — Continuous NHANES study conducted in 2007-2012; ER — proportion of persons with HoTN; NHANES2 — NHANES II study conducted in 1976-1980; n — total number of subjects in the group; P0÷P1 — prevalence confidence interval for p=0,95.

Table 4

Prevalence of HoTN according to the HoTN-4 criterion

Sex and age (years)	Population											
	RF-80			NHANES2			ESSE-RF			C.NHANES		
	A/n	ER	P0÷P1	A/n	ER	P0÷P1	A/n	ER	P0÷P1	A/n	ER	P0÷P1
						Men						
18-24	34/312	10,9	8,1÷14,2	132/843	15,7	13,6÷17,9						
25-34	77/715	10,8	8,9÷12,9	124/901	13,8	11,9÷15,8	129/2049	6,3	5,4÷7,3	118/475	24,8	21,6÷28,3
35-44	289/2885	10,0	9,1÷11,0	60/651	9,2	7,4÷11,3	70/1686	4,2	3,4÷5,0	100/486	20,6	17,6÷23,8
45-54	329/5246	6,3	5,7÷6,9	45/617	7,3	5,7÷9,3	63/2049	3,1	2,5÷3,8	109/514	21,2	18,3÷24,4
>54	82/1974	4,2	3,4÷5,0	88/2126	4,1	3,5÷4,9	42/2091	2,0	1,5÷2,6	88/470	18,7	15,8÷21,9
Total	811/11132	7,3	6,9÷7,7	449/5138	8,7	8,1÷9,4	304/7875	3,9	3,5÷4,2	415/1945	21,3	19,8÷22,9
						Women						
18-24	29/144	20,1	14,8÷26,4	175/890	19,7	17,5÷22,0						
25-34	102/932	10,9	9,3÷12,8	147/994	14,8	13,0÷16,8	217/2330	9,3	8,3÷10,4	133/473	28,1	24,7÷31,7
35-44	56/1431	3,9	3,1÷4,9	54/721	7,5	5,9÷9,3	121/2507	4,8	4,1÷5,6	117/556	21,0	18,2÷24,1
45-54	24/1390	1,7	1,2÷2,4	21/644	3,3	2,2÷4,7	85/3837	2,2	1,8÷2,7	74/529	14,0	11,6÷16,7
>54	9/1847	0,5	0,3÷0,9	43/2411	1,8	1,4÷2,3	46/4467	1,0	0,8÷1,3	75/469	16,0	13,3÷19,0
Total	220/5744	3,8	3,4÷4,3	440/5660	7,8	7,2÷8,4	469/13141	3,6	3,3÷3,9	399/2027	19,7	18,2÷21,2

Note: RF-80 — Russian population studies conducted in 1975-1982; ESSE-RF — study conducted in 2012-2014; A — number of persons with HoTN; C.NHANES — Continuous NHANES study conducted in 2007-2012; ER — proportion of persons with HoTN; NHANES2 — NHANES II study conducted in 1976-1980; n — total number of subjects in the group; P0÷P1 — prevalence confidence interval for p=0,95.

prevalence of HoTN over a 30-year period in Russian men decreased instead of growth according to the HoTN-1 criterion.

Many researchers have described a higher prevalence of HoTN in women [1] and some have recommended sex-differentiated criteria for HoTN. An example is the HoTN-4 criterion [13]. Data on the prevalence of HoTN-4 are presented in Table 4. The ratio of HoNT in men and women changed as expected. The prevalence of HoTN in the Russian population decreased during 30-year period in men in all age groups, while there were changes in women. In the Russian and American populations in the 1980s, the prevalence of HoTN in age groups of men did not differ. Other data are described in Table 1.

It can be assumed that when only BP values are used for HoTN diagnosis, some hypertensive patients receiving antihypertensive drugs may fall

into normotensive and even hypotensive groups. The influence of this factor was studied in Russian studies. The prevalence of HoTN was calculated according HoTN-4 criterion, in which all persons who answered positively to the question of whether they had HTN or taking antihypertensive agents were excluded from HoTN group. There were no differences in the prevalence of HoTN according to HoTN-4 criterion.

As already noted, the prevalence of HoTN has changed significantly over a 30-year period. In the United States, it has increased significantly. The differences are significant according to all the studied criteria in all age groups, both in men and women. In Russian populations, the differences are not so unambiguous. According to the HoTN-1 criterion, the prevalence of HoTN increased in most age groups, while according to other criteria, a decrease was more typical for men, and for women the changes was less pronounced. A large number of factors are known that affect the normal BP, including ambient temperature, atmospheric pressure, and many others. Some of these factors in this study can be ignored, since samples from the population of one country were studied.

Particular attention is drawn to such a factor as mental strain at the population level. In 1931, the role of autonomic nervous system changes under the social influence in HoTN pathogenesis was noted [1]. This is consistent with the well-known pronounced increase in the frequency of HoTN during significant socio-economic disruptions: for example, after the Second World War, the number of hypertensive patients in Germany, compared with the pre-war period, increased by 60%, and the number of people with HoTN — by 120% [1]. In this context, the data on the prevalence of HoTN in the Russian Federation, including the 30-year dynamics, look more favorable in comparison with the USA.

It was shown above how several HoTN criteria work on population material, in which fixed BP values are used, including those differentiated depending on sex and age. It should be noted that such criteria were developed on clinical material and selective samples [1, 12]. Another approach is known based on the assessment of the threshold BP levels by their distribution in the surveyed group [7]. It is impractical to study the prevalence of HoTN according to such criteria, since it will be due to the selected cutoff point.

Conclusion

The prevalence of HoTN in the adult population is at least a few percent. This is a common condition, which explains the practical importance of study, control and prevention of HoTN.

The prevalence of HoTN significantly depends on the selected criterion. This makes relevant the development of a pathophysiologically reasonable criterion. Most of the described criteria do not have such a substantiation. An exception is the HoTN-1 criterion (BP $\leqslant$90/60 mm Hg), which corresponds to a mean BP <70 mm Hg, ie, the threshold BP for maintaining autoregulation of cerebral blood flow [11].

By analogy with the history of hypertension study, it can be assumed that criterion should be associated with the long-term prognosis at the population level.

To compare the prevalence of HoTN in different populations, one of the known criteria can be used, while preference should be given to the simplest ones undifferentiated by age and sex.

The results of this analysis are consistent with data of a number studies with pronounced changes in the prevalence of HoTN in different historical periods. The interpretation of these observations is still difficult.

Acknowledgements. This study was made possible through free access to NHANES research data provided by the National Center for Health Statistics (USA). Authors of the article are responsible for the results of analysis, interpretation and conclusions. The National Center for Health Statistics is responsible only for primary data.

Relationships and Activities. The ESSE-RF study was performed as part of a state assignmen № AAAA-A20-120013090086-0.

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