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# Features of peripheral circulation in young people of different somatotype with normal and high blood pressure

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## Abstract

**Introduction:** Hypertension is the most common disease of the circulatory system. The most relevant area in the assessment of individual human health is the constitutional approach. Many studies have shown that most indicators of the blood circulation are related to anthropometric parameters of the body, which is why studying the features of peripheral hemodynamics in representatives of different somatotypes with normal and high blood pressure is especially relevant.

**The purpose** of the study was to determine the features of peripheral circulation in young people, aged 18 to 22 years, of different somatotype with normal and high blood pressure.

**Materials and methods:** two groups of subjects selected: a control group (CG) — those in which the value of BP consistent optimum level by the WHO classification (125 people), the second group — those in which systolic blood pressure higher than 130 mmHg and (or) diastolic — 85 mmHg (135 people). Somatotyping performed using techniques by Carter and Heath. To study the condition of peripheral hemodynamics used rheovasography of the lower extremities.

**Results and discussion:** statistical analysis of the results by the Kruskal-Wallis method in the individuals of both groups showed a significant difference in the majority of rheovasography indices among subjects of different somatotypes. The method of multiple comparisons showed significant differences in the values of peripheral circulation among representatives of different somatotypes with normal and high blood pressure.

**Conclusions:** peripheral hemodynamics in subjects with normal blood pressure and predominance of the endomorphic component was characterized by significantly higher vascular tone of mainly medium and small diameter compared to ectomorphs. The peripheral circulation of individuals with high blood pressure and predominance of the endomorphic component, compared to ectomorphs and to lesser extent mesomorphs, was characterized by a significantly higher increase in the tone of the small arteries and a decrease in the tone of the large arteries.

**Key words:** hypertension; blood pressure; somatotype; peripheral circulation.

## Introduction

Hypertension (HT) is the most common chronic human disease. Currently, the problem of hypertension can be regarded as a large-scale non-communicable pandemic. The necessity to find the solution for hypertension due to the fact that high blood pressure (BP) is the most important risk factor for cardiovascular disease and mortality [1]. The results of epidemiological studies indicate a fairly large percentage of the prevalence of hypertension in children and adolescents (4-18%) [2]. Among adolescents with blood pressure (BP), higher than the average level, in the future hypertension remains 33-42%, and its progression is observed in 17-26% of cases. Thus, every third adolescent with high blood pressure may have hypertension in adulthood [3].

The pathogenesis of hypertension reflects the complex interaction of internal (genetic) and external factors [4]. Since, somatotype is an indicator of hereditary polymorphism, and may be an important objective criterion functional response of the body [5], it is reasonable to believe that characteristics of not only initially selected anthropometric indicators, but also the composition of the body, the nervous, endocrine, immune and circulatory systems, structures and functions of internal organs are inherent for representatives of each type. This, in turn, can detect the presence of

certain specific hemodynamic parameters that can indicate the presence of potential predisposition of certain somatotype to the development of cardiovascular disease, including hypertension.

Non-invasive, safe and affordable method of assessing peripheral circulation today is rheovasography. The analysis of peripheral blood flow indicators can be used in order to assess the functional state of the cardiovascular system, for timely prediction and diagnosis and premorbid pathological changes of the arterio-venous system [6].

Many studies have shown that most hemodynamic indicators are related to anthropometric parameters of the body [7-9]. The peripheral hemodynamics, especially of the lower extremities, is an important indicator of homeostasis of the organism as a whole, which can be impaired in a number of various diseases, which requires further diagnosis and correction taking into account the individual characteristics of patients [10], including a certain somatotype.

A number of studies were conducted to detect attempts dependence indicators of cardiovascular system of physical parameters that characterize the body as a whole, including length, weight, body surface area, body mass index [6,8,11]. It is established in the scientific literature that the parameters of almost all indicators of central hemodynamics correlate with anthropometric parameters [7,12], however, indicators of peripheral hemodynamics in young individuals of different somatotype with normal and elevated blood pressure have not been sufficiently studied and data on these features are found insufficient, which makes our studies especially relevant as they will facilitate the study of the initial changes in peripheral blood flow even before the onset of clinical symptoms.

**Purpose of the research:** to determine the features of peripheral blood circulation in young people aged 18 to 22 years, of different somatotype with normal and high blood pressure.

**Materials and methods**

Our studies do not contradict the accepted bioethical standards of the Helsinki Declaration adopted by the General Assembly of the World Medical Association on Human Rights, the International Code of Medical Ethics and the laws of Ukraine and can be used in scientific work (decision of the commission on bioethics I. Horbachevsky Ternopil National Medical University, protocol number 54 of 27.08.2019).

The study was conducted at the Ministry of Health of Ukraine certified laboratory of psychophysiological research at the Department of Physiology with the Basics of Bioethics and Biosafety of I. Horbachevsky Ternopil National Medical University (certificate № 055/13).

Two groups of surveyed aged 18 to 22 years were selected. The first control group (CG) included subjects in whom the BP value corresponded to the optimum level according to the WHO classification (125 surveyed). The second group consisted of individuals whose systolic blood

pressure exceeded 130 mmHg and (or) diastolic — 85 mmHg (135 people) at the time of study. Blood pressure was measured by Korotkov's method in a calm condition after a 5-minute rest. The average result was recorded after three times measurement [13].

The somatotyping of the subjects was performed using the Carter and Heath technique recommended for individuals of both sexes aged 14 to 70 years [14]. This technique is based on the determination of three somatotype components: endomorphy, mesomorphy, and ectomorphy, which are always expressed in the same order. Endomorphy reflects the total fat content of the human body, mesomorphy characterizes the development of skeletal muscle, and ectomorphy reflects the slimness of the body and the extent of its elongation. Thanks to the formulas proposed by the authors, each component is objectively identified and a somatotyping scheme establishes a specific human somatotype. In characterizing the mixed somatotypes we have selected, the predominant component is in second place, and the next, larger, in first, third component is not taken into account, since it is the smallest somatotype component.

The survey was conducted by computer rheographic complex «Reocom» (manufactured at scientific and technical center «KAI-Medica» Kharkiv, Ukraine). Rheovasographic examination was performed on an empty stomach or not earlier than 2 hours after eating, in the horizontal position of the subject, after 10-15 minutes of rest, at an air temperature not lower than +20ºC. We used tape-like, paired electrodes, which were applied to the upper and lower thirds of the right and left shins, with the electrodes measuring voltage (I) were placed outside, and the current (U) to the middle. Before applying the electrodes, the skin was degreased with 70% ethyl alcohol.

For analysis, 15-second rheogram records were used, followed by automatic averaging of all oscillation periods [15]. The analysis of the quantitative parameters of the shin rheovasogram was performed by time, amplitude and integral (derived from amplitude and time) indicators.

The study results were statistically processed using Analyst Soft Stat Plus 6. The probability was estimated using the nonparametric statistics method. We used the Kruskal-Wallis test to compare the likelihood of differences between independent samples with unequal numbers of observations and the multiple comparison method [16].

**Results and discussion**

Using the somatotyping technique, 6 mixed somatotypes were identified among all of surveyed: mesomorphic endomorph, mesomorphic ectomorph, endomorphic mesomorph, ectomorphic endomorph, endomorphic ectomorph, ectomorphic mesomorph.

Statistical analysis of results by Kruskal-Wallis in control group showed the presence of significant differences for systolic wave amplitude parameters ($p=0.0004$), diastolic wave amplitude ($p=0.0005$), the amplitude of the rapid blood flow ($p=0.0025$), tone of great arteries ($p=0.0050$), time of rapid blood flow ($p=0.0001$), slow blood flow time ($p=0.0001$), maximal blood flow rate

(p=0.0001), average slow blood flow rate (p=0.0001) and the coefficient of peripheral resistance (p=0.0005).

The multiple comparison method we used showed that the amplitude indices of the lower extremity rheogram had significant differences when comparing the examined CGs that belonged to different somatotypes. The systolic wave amplitude in mesomorphic ectomorphs was significantly higher compared to mesomorphic (p=0.0039) and ectomorphic endomorphs (p=0.0050). Diastolic wave amplitude was higher in ectomorphic endomorphs and had a statistically significant difference with mesomorphic (p=0.0034) and endomorphic (p=0.0053) ectomorphs (Table 1).

Table 1. Indicators of peripheral hemodynamics in surveyed of different somatotype with normal blood pressure.

| Indicator | Somatotypes | | | | | |
|---|---|---|---|---|---|---|
| | Mean ±Std. Error Mean | | | | | |
| | mesomorphic endomorphs n=23 | mesomorphic ectomorphs n=20 | endomorphic mesomorphs n=22 | ectomorphic endomorphs n=20 | endomorphic ectomorphs n=20 | ectomorphic mesomorphs n=20 |
| Time of rapid blood flow, sec | 0.038±0.008 | 0.039±0.003 | 0.031±0.010 | 0.031±0.001 | 0.040±0.003 | 0.030±0.003 |
| Slow blood flow time, sec | 0.073±0.009 | 0.048±0.002 | 0.050±0.001 | 0.058±0.001 | 0.050±0.007 | 0.064±0.003 |
| Systolic wave amplitude, Ohm | 0.046±0.009 | 0.062±0.004 | 0.049±0.002 | 0.042±0.001 | 0.051±0.005 | 0.055±0.011 |
| Diastolic wave amplitude, Ohm | 0.023±0.004 | 0.013±0.001 | 0.015±0.001 | 0.019±0.001 | 0.013±0.001 | 0.018±0.001 |
| Maximal blood flow rate, Ohm/ sec | 0.847±0.163 | 1.191±0.093 | 0.990±0.046 | 0.838±0.063 | 1.108±0.086 | 1.194±0.091 |
| Peripheral resistance coefficient, cond. units | 68.216±4.796 | 62.900±1.033 | 64.534±0.621 | 65.136±1.251 | 59.077±0.635 | 60.187±1.650 |
| Tone of large arteries, cond. units | 0.779±0.059 | 0.817±0.018 | 0.751±0.024 | 0.664±0.025 | 0.825±0.080 | 0.731±0.070 |
| Tone of medium and small arteries, cond. units | 0.479±0.038 | 0.433±0.007 | 0.424±0.012 | 0.445±0.016 | 0.478±0.035 | 0.481±0.017 |
| Amplitude of the rapid blood flow, Ohm | 0.024±0.004 | 0.030±0.001 | 0.035±0.002 | 0.029±0.002 | 0.042±0.007 | 0.038±0.004 |
| Average slow blood flow rate, Ohm/sec | 0.378±0.075 | 0.326±0.009 | 0.345±0.009 | 0.371±0.010 | 0.334±0.015 | 0.317±0.009 |

Note. The validity between the groups of different somatotypes surveyed is indicated in the text.

When comparing the amplitude of the rapid blood flow, a significant difference was found in its value in mesomorphic endomorphs, in which the indicator was lower compared to ectomorphic (p=0.0239) and endomorphic (p=0.0011) mesomorphs. The tone of the large arteries of mesomorphic ectomorphs was also found to be significantly higher compared to ectomorphic endomorphs (p=0.0047). Assessing the time indexes of the lower extremity rheogram in CG patients, we found that the time of rapid blood flow of endomorphic mesomorphs was significantly lower, compared to subjects with predominance of the ectomorphic component of the somatotype (p=0.0001). The slow blood flow time of mesomorphic ectomorphs was lower and had a significant difference with ectomorphic endomorphs (p=0.0376) and ectomorphic mesomorphs (p=0.0016). This indicator was also significantly higher among ectomorphic mesomorphs compared to endomorphic mesomorphs (p=0.0147). However, the highest this indicator was recorded in mesomorphic endomorphs and this was statistically different from endomorphic mesomorphs (p=0.0025) and individuals with predominant ectomorphic component (p=0.0127, p=0.0002). A significant difference in maximal blood flow rate was found between mesomorphic endomorphs, in which it was significantly lower compared to ectomorphic mesomorphs (p=0.0052), mesomorphic (p=0.0056) and endomorphic (p=0.0027) ectomorphs. In endomorphic ectomorphs, the maximum rate of blood flow was significantly higher compared to ectomorphic endomorphs (p=0.0350). The examined endomorphic ectomorphs had a lower average slow blood flow rate than the endomorphic mesomorphs (p=0.0011) and those surveyed with a predominance of the endomorphic component of the somatotype (p=0.0352, p=0.0003). However, this indicator was found to be significantly higher in endomorphic ectomorphs compared to mesomorphic ectomorphs (p=0.0004) and ectomorphic mesomorphs (p=0.0001). The coefficient of peripheral resistance among endomorphic ectomorphs was significantly lower, which was a significant difference with the representatives of endomorphic mesomorphs (p=0.0116) and individuals whose somatotype was dominated by the endomorphic component (p=0.0028, p=0.0160) (Table 1).

Thus, we found that in CG patients with predominance of the endomorphic component in somatotype, regional hemodynamics is characterized by a more pronounced increase in the tone of the medium and small arteries, as well as a lower amplitude of the systolic wave, the amplitude of rapid blood flow and the increase of the diastolic rate amplitude. It was also found that the tone of the large arteries and the maximal rate of blood flow were the lowest, and the time of slow blood flow, the average rate of slow blood flow and the coefficient of peripheral resistance were significantly higher compared to subjects in whom the ectomorphic component predominated.

Applying the Kruskal-Wallis method in the analysis of rheography indices in individuals with high blood pressure, we established a significant difference in the systolic wave amplitude (p=0.0113), diastolic wave amplitude (p=0.0001), the amplitude of the rapid blood flow (p=0.0025), the tone of the large arteries (p=0.0001), the tone of the medium and small arteries (p=0.0001), the

time of rapid blood flow (p=0.0001), the time of slow blood flow (p=0.0004), the average rate of slow blood flow (p=0.0033) and the coefficient of peripheral resistance (p=0.0001). Using the multiple comparison method, we found the difference between the mean values of the systolic wave amplitude in ectomorphic endomorphs and endomorphic ectomorphs in which it was significantly higher (p=0.0093).

Analyzing the magnitude of the diastolic wave amplitude, we found significantly higher values of this indicator in mesomorphic endomorphs compared to all ectomorphs (p=0.0006, p=0.0002) and ectomorphic mesomorphs (p=0.0005). An increase in this indicator was observed in ectomorphic endomorphs, compared to ectomorphic mesomorphs (p=0.0009) and individuals with ectomorphic predominance (p=0.0005, p=0.0308). The diastolic wave amplitude was also significantly higher in endomorphic mesomorphs compared to endomorphic ectomorphs (p=0.0053) and ectomorphic mesomorphs (p=0.0091) (Table 2).

Table 2. Indicators of peripheral hemodynamics in subjects of different somatotype with high blood pressure.

| Indicator | Somatotypes | | | | | |
|---|---|---|---|---|---|---|
| | Mean ±Std. Error Mean | | | | | |
| | mesomorphic endomorphs n=30 | mesomorphic ectomorphs n=20 | endomorphic mesomorphs n=25 | ectomorphic endomorphs n=20 | endomorphic ectomorphs n=20 | ectomorphic mesomorphs n=20 |
| Time of rapid blood flow, sec | 0.031±0.002 | 0.041±0.002 | 0.031±0.001 | 0.033±0.010 | 0.050±0.004 | 0.046±0.004 |
| Slow blood flow time, sec | 0.095±0.023 | 0.056±0.003 | 0.072±0.005 | 0.069±0.004 | 0.057±0.005 | 0.072±0.003 |
| Systolic wave amplitude, Ohm | 0.065±0.008 | 0.058±0.013 | 0.054±0.006 | 0.044±0.005 | 0.067±0.006 | 0.055±0.009 |
| Diastolic wave amplitude, Ohm | 0.030±0.002 | 0.018±0.003 | 0.023±0.002 | 0.026±0.002 | 0.013±0.002 | 0.014±0.002 |
| Maximal blood flow rate, Ohm/ sec | 0.836±0.057 | 0.897±0.145 | 0.913±0.090 | 0.814±0.071 | 1.048±0.085 | 0.881±0.110 |
| Peripheral resistance coefficient , cond. units | 87.19±2.105 | 66.181±4.044 | 73.540±3.660 | 78.280±3.929 | 71.060±1.694 | 72.195±1.080 |
| Tone of large arteries, cond. units | 1.135±0.098 | 0.918±0.045 | 1.118±0.177 | 0.651±0.066 | 0.956±0.032 | 1.035±0.075 |
| Tone of medium and small arteries, cond. units | 0.784±0,042 | 0.530±0.049 | 0.650±0.029 | 0.642±0.038 | 0.542±0.046 | 0.565±0.022 |
| Amplitude of the rapid blood flow, Ohm | 0.026±0.003 | 0.042±0.008 | 0.023±0.003 | 0.018±0.003 | 0.053±0.014 | 0.028±0.004 |
| Average slow blood flow rate, Ohm/sec | 0.657±0.078 | 0.418±0.104 | 0.511±0.036 | 0.542±0.033 | 0.477±0.060 | 0.534±0.033 |

Note. The validity between the groups of different somatotypes surveyed is indicated in the text.

The amplitude of the rapid blood flow in ectomorphic endomorphs was significantly lower and differed from mesomorphic (p=0.0334) and endomorphic ectomorphs (p=0.0021). Also, in subjects with high blood pressure, the mean values of large artery tone in ectomorphic endomorphs were significantly lower compared to mesomorphic endo- (p=0.0001), ectomorphs (p=0.0175), endomorphic ectomorphs (p=0,0041) and individuals with predominance of the mesomorphic component of the somatotype (p=0.0030, p=0.0006). Medium and small artery tone was significantly higher among mesomorphic endomorphs, compared to endomorphic (p=0.0001) and mesomorphic (p=0.0001) ectomorphs, as well as ectomorphic mesomorphs (p=0.0002). Medium and small artery tone in endomorphic mesomorphs was significantly higher compared to endomorphic ectomorphs (p=0.0305) (Table 2).

The time indices of the lower extremity rheogram in individuals with high blood pressure had significant differences when compared to subjects with high blood pressure, who belonged to different somatotypes. It was found that the time of rapid blood flow in mesomorphic endomorphs was significantly lower compared to mesomorphic (p=0.0219) and endomorphic ectomorphs (p=0.0013), as well as to ectomorphic mesomorphs (p=0.0117). Mesomorphic ectomorphs showed a higher rapid blood flow time index, which was statistically significant compared to endomorphic mesomorphs (p=0.0360) and ectomorphic endomorphs (p=0.0035). It was also found that this indicator was significantly lower in endomorphic mesomorphs and ectomorphic endomorphs, compared to endomorphic ectomorphs (p=0.0028) and ectomorphic mesomorphs (p=0.0201). The slow blood flow time in mesomorphic endomorphs was significantly higher compared to mesomorphic (p=0.0169) and endomorphic ectomorphs (p=0.0147). This figure was also significantly higher in ectomorphic mesomorphs compared to ectomorphs (p=0.0310, p=0.0350). Significantly lower average rate of slow blood flow was observed in mesomorphic ectomorphs, compared to ectomorphic mesomorphs (p=0.0257) and individuals with predominance of endomorphic component (p=0.0040, p=0.0219). The highest coefficient of peripheral resistance was recorded in mesomorphic endomorphs and this had a statistically significant difference with all surveyed that had prevalence of ectomorphic (p=0.0008, p=0.0004) and mesomorphic (p=0.0085, p=0.0004) components (Table 2).

Thus, in subjects with high blood pressure, in which the endomorphic component in the somatotype predominated, a significant increase in the tone of the medium and small arteries of the lower extremities was established, which is confirmed by significantly lower magnitudes of the systolic wave amplitudes and rapid blood flow and increasing the amplitude of the diastolic wave. The magnitude of peripheral resistance in these patients was also the highest and was mainly due to the increase in the tone of the medium and small arteries, which led to an increase in time and a decrease in the average rate of slow and fast blood flow. These examinations also revealed a

decrease in the tone of the large arteries, which could be considered as a compensatory reaction for stabilization of peripheral hemodynamics.

In subjects with high blood pressure and dominance of the ectomorphic component in the somatotype, peripheral hemodynamics was characterized by an increase in blood flow velocity, which is indicated by the presence of the highest systolic wave amplitude and fast blood flow amplitude, compared to representatives of other somatotypes. The diastolic wave amplitude, the tone of the medium and small arteries, and the time of slow blood flow in these patients were the lowest among all somatotypes of the group with elevated blood pressure, but significantly higher compared to the ectomorphs of CG. The index of tone of the large arteries was intermediate, compared to the representatives of other somatotypes, but it was the highest among the representatives of the mesomorphic somatotype. All other indicators of rheogram in subjects with high blood pressure, in which the mesomorphic component in the somatotype predominated, occupied an intermediate value.

**Conclusions**

1. Peripheral hemodynamics in subjects with normal blood pressure and predominance of the endomorphic component in somatotype (mesomorphic endomorph, ectomorphic endomorph) was characterized by significantly higher vascular tone of mainly medium and small diameter arteries compared to ectomorphs and mesomorphs.
2. In subjects with high blood pressure of all somatotypes, the peripheral resistance was significantly higher compared to those with normal blood pressure due to the higher tone of medium and small caliber arteries.
3. The peripheral circulation of subjects with high blood pressure and predominance of the endomorphic component in somatotype, compared to ectomorphs and less mesomorphs, was characterized by a significantly higher increase in the tone of the small arteries and a decrease in the tone of the large arteries.

**References**:


1. Sirenko JuN. Klassifikacija, diagnostika i stratifikacija riska pri arterial'noj gipertenzii. [Risk classification, diagnosis and stratification in hypertension]. Novosti mediciny i farmacii Arterial'naja gipertenzija (tematicheskij nomer). 2007;25–6. Ukrainian.
2. Ivanytska TA, Burmak YuH, Ivanytskyi IV. Vplyv faktora spadkovosti na rozvytok pervynnoi arterialnoi hipertenzii u patsiientiv molodoho viku. [Influence of heredity factor on the development of primary hypertension in young patients]. Zdobutky klinichnoi i eksperymentalnoi medytsyny. 2018;1:261–3. Ukrainian.
3. Bohmat LF, Ponomarova LI. Poshyrenist arterialnoi hipertenzii ta yii faktoriv ryzyku u shkoliariv populiatsii m. Kharkova. [Prevalence of hypertension and its risk factors in schoolchildren of Kharkiv population]. Arteryalnaia hypertenzyia. 2009;2(4):69-70. Ukrainian.
4. Leljuk VG, Leljuk SJe. Cerebral'noe krovoobrashhenie i arterial'noe davlenie. [Cerebral circulation and blood pressure]. M.; 2004. 303 p. Russian.
5. Singh IP, Bhasin MK. Somatotyping. B: A Manual Of Biological Anthropology. Kamla Raj Enterprises; 2004. p 253–256.
6. Khapitska OP, Ivanytsia AO, Stefanenko IS, Sarafyniuk LA, Moroz VM. Zminy reohrafichnykh pokaznykiv homilky u sportsmeniv riznykh vydiv sportu. [Changes in the rheographical values in athletes of different sports]. Fiziolohichnyi zhurnal. 2017;63(1):51–9. Ukrainian.
7. Bobrovska OA. Koreliatsii mizh obkhvatnymy rozmiramy verkhnikh i nyzhnikh kintsivok z parametramy tsentralnoi hemodynamiky u pidlitkiv v zalezhnosti vid somatotypu. [Correlations between the circumferential dimensions of the upper and lower extremities with the parameters of central hemodynamics in adolescents depending on the somatotype]. Svit medytsyny ta biolohii. 2008;(4):16–23. Ukrainian.
8. Ivanytsia AO. Koreliatsii chasovykh i amplitudnykh pokaznykiv reovazohramy homilky z antropo - somatotypolohichnymy parametramy u zdorovykh yunakiv i divchat Podillia. [Correlation of temporal and amplitude indices of the shin rheovasogram with anthropo - somatotypological parameters in healthy boys and girls of Podillia]. Ukrainskyi morfolohichnyi almanakh. 2014;12(1):52–6. Ukrainian.
9. Bobrovska OA. Morfofunktsionalni koreliatsii na prykladi vzaiemozviazkiv shyryny dystalnykh epifiziv plecha, peredplichchia, stehna ta homilky z pokaznykamy tsentralnoi hemodynamiky u praktychno zdorovykh pidlitkiv riznykh somatotypiv. [Morphofunctional correlations based on the relationship of the width of the distal epiphyses of the shoulder, forearm, thigh and lower leg with indicators of central hemodynamics in practically healthy adolescents of different somatotypes]. Morfolohiia. 2008;2(2):5–9. Ukrainian.
10. Vadziuk SN, Hunas IV, Tsvyntarnyi AV. Osoblyvosti zviazkiv reovazohrafichnykh indeksiv i pokaznykiv tonusu arterii stehna z antropometrychnymy y somatotypolohichnymy parametramy zdorovykh miskykh yunakiv i divchat Podillia. [Features of correlation of rheovasographic indices and thigh artery tone indices with anthropometric and somatotypological parameters of healthy urban boys and girls of Podillya]. Svit medytsyny ta biolohii. 2014;3(45):18–22. Ukrainian.
11. Moroz VM, Khapitska OP, Sarafyniuk LA. Osoblyvosti vzaiemozviazkiv reovazohrafichnykh parametriv stehna z pokaznykamy zovnishnoi budovy tila u sportsmeniv riznykh vydiv sportu. [Features of the relationship of the rheovasographic parameters of the thigh with the indicators of the external structure of the body in athletes of different sports]. Visnyk morfolohii. 2016;22(2):372–9. Ukrainian.

12. Datsenko HV. Koreliatsii pokaznykiv reoentsefalohramy z pokaznykamy budovy i rozmiriv tila praktychno zdorovykh divchat Podillia. [Correlation of rheoencephalogram indices with indicators of structure and body size of healthy girls in Podillya]. Biomedychna i biosotsialna antropolohiia. 2016;99(27):72–6. Ukrainian.

13. Svishchenko YeP, Bahrii AE, Yena LM. Rekomendatsii Ukrainskoi asotsiatsii kardiolohiv z profilaktyky ta likuvannia arterialnoi hipertenzii. [Recommendations of the Ukrainian Association of Cardiologists for the Prevention and Treatment of Hypertension]. Kyiv: PP VMB; 2008. 72 p. Ukrainian.

14. Carter JEL, Heath BH. The Heath-Carter Anthropometric Somatotype. Somat Instr Man. 2002;(March):1–26.

15. Ivanov L, Makarov V. Lekcii po klinicheskoj reografii. [Lectures on clinical rheography]. Moskva: MBN; 2000. 319 p. Russian.

16. Ungurjanu TN, Grzhibovskij AM. Sravnenie treh i bolee nezavismyh grupp s ispol'zovaniem neparametricheskogo kriterija Kraskela – Uollisa v programme Stata. [Comparison of three or more independent groups using the non-parametric Kruskal-Wallis test in the Stata program]. Jekologija cheloveka. 2014;(6):55–8. Russian.