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MODELING OF INDIVIDUAL INDICATORS OF CEREBRAL BLOOD CIRCULATION IN DEPENDENCE FROM ANTHROPOS-SOMATOMETRIC PARAMETERS OF PRACTICALLY HEALTHY WOMEN OF THE MEDIUM INTERMEDIATE SOMATOTYPE

Summary. *The article describes and analyzes the regression models of individual indicators of cerebral circulation in practically healthy women of the middle intermediate somatotype on the basis of their anthropometric, somatotypological indices and components of the body mass index. Simulated 17 out of 18 studied cerebral blood flow parameters with a determination coefficient R2 greater than 0.6, including 5 models of amplitude (R2 from 0.783 to 0.868), 5 time (R2 from 0.752 to 0.882) and 7 derivatives (R2 from 0.639 to 0.888) indicators of reoencephalogram. The built-up models of the amplitude indices of the reoencephalogram most often include the circumferential dimensions of the body (29.0%), the longitudinal dimensions of the body (22.6%), the thickness of skin and fat folds (19.4%) and the diameters of the body (12.9%); to the models of the time indices of the reoencephalogram - the circumferential dimensions of the body (51.6%), body diameters (19.4%) and the width of distal epiphyses of the long tubular bones of the limbs (12.9%); to the models of derivative indices of the reoencephalogram - the circumferential dimensions of the body (27.9%), body diameters (18.6%), cephalometric indices, longitudinal body sizes, thickness of skin and fat folds and width of distal epiphyses of long limb bones (by 11.6%).*
Key words: *practically healthy female of medium intermediate somatotype, cerebral hemodynamics, anthropometric indices, regression models.*

Introduction

The high social significance of circulatory disorders in the vessels of the brain determines the increased interest of scientists and clinicians in the study of the properties of cerebral hemodynamics [3]. As one of the approaches to researching and forecasting processes of blood circulation in the vessels of the brain, the most optimal is the mathematical analysis of hemodynamic processes (most often, the parameters of reoencephalography) [2, 8].

However, great difficulty is the application of mathematical methods in the modeling of cerebral circulation of a person. This is due to both morphological and functional characteristics, and the complexity, multiplicity of vascular reactions in individuals of different constitutional types [12]. In this situation it is necessary to search for the most informative system of indicators of physical development and conduct their further ranking. The construction of regression equations involves an appeal to the system analysis of this phenomenon, its main components and their relationships, the decision on the nature of established regularities [10].

There are very little works relating to the construction and analysis of regression models of individual indicators of cerebral circulation, depending on anthropometric-somatometric parameters of the body in practically healthy persons [6, 13].

The *purpose* of the study is to construct and analyze a regression model of individual indicators of cerebral circulation, depending on the anthropometric and somatometric parameters of the body of practically healthy women of the middle intermediate somatotype.

Materials and methods

The results of anthropo-somatotypological and reoencephalographic studies that were conducted in practically healthy urban women of the Podillia region of Ukraine were taken from the data bank of the Research center of the National Pirogov Memorial Medical University, Vinnytsya.

The reoencephalographic parameters were obtained using a computer diagnostic complex. As a result of processing, the rheograms automatically determined the characteristic points on the curve, determined the main indicators, formulated and substantiated the conclusion about the state of the circulatory system of the investigated area [15]. The following parameters of the reoencephalogram were determined: *amplitude* - basic impedance (EZ, Ohm); amplitude of systolic wave (EH1, Ohm); incidence amplitude (EH2, Ohm); amplitude of the diastolic wave (EH3, Ohm); amplitude of the phase of rapid blood filling (EH4, Ohm); *time* - duration of the heart cycle (EC, s); the duration of the ascending part (EA, s); the duration of the downward part (EB, s); duration of fast blood filling phase (EA1, s); duration of the phase of slow blood filling (EA2, s); *derivatives* - dicrotic index (EH2H1,%); diastolic index (EH3H1,%); average speed of the fast blood filling phase (EH4A1, Ohm/sec); average speed of the phase of slow blood flow (EH4A2, Ohm/sec); index of total arterial tone (EAC,%); index of tone of arteries of large caliber (arteries of distribution) (EA1C,%); mean tone of arteries of medium and small caliber (arteries of resistance) (EA2C,%); the ratio of tone of arteries of different caliber (EA1A2,%).

Anthropometric study conducted in accordance with the scheme of V.V. Bunak [4] included definition of: total, longitudinal, transverse, circumflex body size, pelvic size and thickness of skin and fat folds (TSFF). Craniometry included a definition: the girth of the head (glabella), sagittal arc, the largest length and width of the head, the smallest head width, face width and mandible [1]. The somatotype is determined by the method of J. Carter and B. Heath [5], and the component composition of the mass of the body - according to the method of J. Matiegka [11] and additionally the muscular component - according to the formulas of the American Institute of Nutrition [9].

The construction of regression models of individual indicators of cerebral circulation, depending on the anthropometric-somatometric parameters of the body, in practically healthy women of the middle intermediate somatotype was carried out in the licensed statistical package "STATISTICA 6.0".

Results. Discussion

As a result of our research, we have developed mathematical models for practically all indicators of cerebral circulation in healthy women of the middle intermediate somatotype. Only the dicrotic index depends on the total complex of anthropometric and somatotypological characteristics of the organism less than 50% and therefore is not essential for practical medicine.

Models of individual indicators of cerebral circulation in practically healthy women of the middle intermediate somatotype with a determination coefficient R2 greater than 0.6 have the form of the following linear equations (in the equations below F is Fisher's criterion, Std Error of estimate is the standard error of regression estimation):

EZ (base impedance) = - 17,79 + 1,546 x height of the swing point - 1,354 x height of the finger point + 2,968 x shoulder girth in the not tense state - 2,573 x interstitial distance of the pelvis + 5,781 x forearm circumference in the lower third - 0,980 x TSFF on the side (R^2 = 0.868; $F_{(6.16)}$ = 17.50; p<0,001; Std. Error of estimate: 5,386);

EH1 (systolic wave amplitude) = 0,076 + 0,003 x height of the swing point - 0,013 x foot circumference + 0,006 x TSFF under the shoulder - 0,003 ? TSFF on the shoulder back surface + 0,005 x maximum length of the head - 0,004 x shoulder grip in the not tense condition (R^2 = 0.805; $F_{(6.16)}$ = 10.99; p<0,001; Std. Error of estimate: 0,012);

EH2 (incisura amplitude) = - 0,179 + 0,002 x chest girth with calm breathing - 0,009 x foot circumference + 0,002 x height of the swivel point - 0,004 x muscle mass component of body by Matiegka + 0,036 x width of the distal shoulder epiphysis + 0,004 x anteroposterior size of the thorax - 0.004 x the pelvic intercostal distance (R^2 = 0.864; $F_{(7.15)}$ = 13.62; p<0,001; Std. Error of estimate: 0,010);

EH3 (amplitude of the diastolic wave) = - 0,084 + 0,002 x chest circumflex at rest in the breath - 0,008 x foot circumference + 0,003 x height of the swivel point + 0,005 x TSFF on the chest - 0,002 x height of the over-thoracic point + 0,022 x width of the distal shoulder epiphysis (R^2 = 0.792; $F_{(6.16)}$ = 10.14; p<0,001; Std. Error of estimate: 0,011);

EH4 (amplitude of the fast blood flow filling phase) = - 0,082 + 0,001 x height of the swivel point - 0,005 x foot circumference + 0,002 x transverse lower-thoracic size + 0,007 x width of the distal epiphyses of the thigh - 0,002 x TSFF on the shoulder back surface + 0,002 x TSFF on the shin (R^2 = 0.783; $F_{(6.16)}$ = 9.64; p<0,001; Std. Error of estimate: 0,006);

EC (duration of the heart cycle) = 0,528 + 0,055 x front and rear size of the chest + 0,030 x transverse lower limb size - 0,073 x inter-swivel distance of the pelvis + 0,056 x foot circumference - 0,053 x brush circumference + 0,035 x leg circumference in the lower third (R^2 = 0.795; $F_{(6.16)}$ = 10.35; p<0,001; Std. Error of estimate: 0,079);

EA (duration of the ascending part of the rheogram) = - 0,025 + 0,005 x upper leg shin circumference - 0,014 x forearm circumference in the lower third + 0,006 x head circumference + 0,003 x TSFF on the side - 0,005 x hip circumference + 0,003 x muscle mass component body by Matiegka (R^2=0,808; $F_{(6,16)}$=11,23; p<0,001; Std. Error of estimate: 0,007);

EB (length of the descending part of the rheogram) = 1,130 + 0,050 x front and rear size of the chest - 0,179 x width of the distal hip epiphysis + 0,179 ? width of the distal epiphysis of the leg - 0,026 x inter-swivel distance of the pelvis + 0,040 x greatest length of the head - 0,061 x forearm girth in lower third (R^2=0,752; $F_{(6,16)}$=8,10; p<0,001; Std. Error of estimate: 0,086);

EA1 (duration of fast blood flow phases) = - 0,040 + 0,003 x upper leg shin circumference - 0,004 x width of distal hip epiphysis - 0,002 x foot circumference - 0,003 x face width + 0,001 x head circumference + 0,001 x pelvic intercostal distance (R^2=0,882; $F_{(6,16)}$=19,87; p<0,001; Std. Error of estimate: 0,002);

EA2 (duration of the phase of slow blood filling) = 0,015 - 0,010 x forearm circumference in the lower third + 0,003 x head circumference + 0,002 x TSFF on the side + 0,003 x forearm circumference in the upper third - 0,003 x hip circumference + 0,005 x circumference of upper part of shin - 0.011 x width of the distal shin epiphysis (R^2=0,789; $F_{(7,15)}$=8,02; p<0,001; Std. Error of estimate: 0,006);

EH3H1 (diastolic index) = - 158.6 - 9.690 x width of the mandible + 8.908 x neck circumference - 6.231 x inter-swivel distance of the pelvis + 4.938 x foot circumference - 2.684 x TSFF on the abdomen + 2.072 x height of the swivel point (R^2=0,888; $F_{(6,15)}$=19,81; p<0,001; Std. Error of estimate: 7,701);

EH4A1 (average speed of the fast blood flow phase) = - 0,253 + 0,153 x face width - 0,089 x lowest head width - 0,074 x foot circumference + 0,023 x height of the swivel point (R^2=0,659; $F_{(4,18)}$=8,69; p<0,001; Std. Error of estimate: 0,130);

EH4A2 (average speed of the slow blood flow phase) = - 0,674 + 0,143 x forearm circumference in the lower third - 0,097 x foot circumference + 0,015 x height of the swivel point - 0,093 x forearm circumference in the upper third + 0,028 x height of the pubic point - 0,036 x leg circumference in upper third + 0,032 x intervertebral pelvic distance (R^2=0,813; $F_{(7,15)}$=9,34; p<0,001; Std. Error of estimate: 0,094);

EAC (tone of all arteries) = - 9,377 + 3,472 x width of the distal femoral epiphysis - 0,411 x TSFF on the front of the shoulder - 4,320 x width of the distal epiphysis of the leg - 0,602 x front and rear size of the chest + 0,799 x shin circumference in the upper third + 1,736 x ectomorphic component of the somatotype + 0.396 x TSFF on the tibia (R^2=0,878; $F_{(7,15)}$=15,44; p<0,001; Std. Error of estimate: 1,085);

EA1C (tone index of large caliber arteries) = 14,37 + 0,512 x muscle mass component of the body for Matiegka - 0,328 x front and rear size of the chest - 0,299 x transverse lower limb size + 0,308 x TSFF under the shoulder blade - 0,292 x circumference of shoulder in the stress state + 0,466 x forearm circumference in the lower third - 8,061 x body surface area (R^2=0,845; $F_{(7,15)}$=11,69; p<0,001; Std. Error of estimate: 0,532);

EA2C (mean tone of arteries of medium and shallow caliber) = - 3,843 + 3,763 x width of the distal hip epiphysis - 0,597 x inter-crested distance - 2,160 x width of the distal epiphysis of the leg - 0,322 x front and rear size of the chest + 0,482 x interstitial distance of the pelvis + 0,749 x brush circumference - 0,397 x greatest head length (R^2=0,855; $F_{(7,15)}$=12,59; p<0,001; Std. Error of estimate: 0,778);

EA1A2 (arterial tone ratio) = - 92.86 - 2.229 x TSFF on chest + 4.239 x sagittal arc + 1.698 x height of over-thoracic point - 14.22 x width of distal femoral epiphysis - 0.832 x chest circumference at maximum exhalation (R^2=0,639; $F_{(5,17)}$=6,01; p<0,01; Std. Error of estimate: 7,346);

where, *the longitudinal dimensions of the body* - in cm; *girth dimensions of the body* - in cm; *transverse body dimensions* - in cm; *TSFF* - in mm; *indicators of the body composition of the component* - in kg; *cephalometric indices* - in cm; *components of somatotype* - in points; *body surface area* - in m^2.

Thus: all five possible amplitude rheoencephalogram parameters with a determination coefficient R2 from 0.783 to 0.868 have been constructed; all 5 possible time indices of the reoencephalogram with determination coefficient R2 from 0.752 to 0.882; of the 8 possible derivatives of the rheoencephalogram, 7 with a determination coefficient R2 from 0.639 to 0.888 were constructed.

Constructed models with a determination coefficient of more than 0.6 most often include:

for amplitude parameters of the reoencephalogram - the circumferential dimensions of the body (29.0%), the longitudinal dimensions of the body (22.6%), TSFF (19.4%) and body diameters (12.9%);

for the time parameters of the rheoencephalogram - the circumferential dimensions of the body (51.6%), body diameters (19.4%), and the width of distal epiphyses of long tubular bones of the extremities (12.9%);

for derivative indices of the reoencephalogram - the circumferential dimensions of the body (27.9%), body diameters (18.6%), cephalometric indices, longitudinal body dimensions, TSFF and width of distal epiphyses of long limb bones (by 11.6%).

The results of modeling obtained by us in women of the middle intermediate somatotype differ from the results of ectomorphic (models of time indicators most often included the circumferential dimensions of the body, TSFF, cephalometric indices and body diameters, and to the amplitude and derivative indices, in addition widths distal epiphyses of long tubular limb bones) [7] and mesomorphic somatotypes (models of amplitude and time indices of reoencephalograms most frequent included circumferential body dimensions, cephalometric indices, TSFF and diameters of the body) [14], which confirms the importance of interpreting the data of reoencephalography, taking into account the constitutional features of the organism.

Conclusions and perspectives of further development

1. In practically healthy women of the middle intermediate somatotype, 17 of 18 possible investigated indicators of cerebral circulation were constructed depending on the peculiarities of their anthropometric, somatotypological and body composition components (5 models of amplitude reoencephalograms parameters with a determination coefficient from 0.783 to 0.868; 5 models of reoencephalogram time indices with a determination coefficient from 0.752 to 0.882; 7 models of derivative indices of reoencephalogram with a determination coefficient from 0.639 to 0.888).

2. Among the anthropo-somatotypological indicators models of amplitude indicators of the reoencephalogram most often include circumferential, longitudinal body size and thickness of skin and fat folds, and to models of time and derivative indicators of the reoencephalogram - the circumferential dimensions and diameters of the body.

The construction of regression models of individual indicators of cerebral circulation, depending on anthropometric and somatometric parameters of the body of practically healthy women of different somatotypes is relevant for the planning of anthropological research and is an indispensable condition for the construction and further effective use of prognostic mathematical models.

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Серебреннікова О.А., Семенченко В.В., Шепітько К.В.
МОДЕЛЮВАННЯ ІНДИВІДУАЛЬНИХ ПОКАЗНИКІВ ЦЕРЕБРАЛЬНОГО КРОВООБІГУ В ЗАЛЕЖНОСТІ ВІД АНТРОПО-СОМАТОМЕТРИЧНИХ ПАРАМЕТРІВ ТІЛА ПРАКТИЧНО ЗДОРОВИХ ЖІНОК СЕРЕДНЬОГО ПРОМІЖНОГО СОМАТОТИПУ

Резюме. *В статті описані і проаналізовані регресійні моделі індивідуальних показників церебрального кровообігу у практично здорових жінок середнього проміжного соматотипу на основі урахування їх антропометричних, соматотипологічних показників та показників компонентного складу маси тіла. Змодельовано 17 з 18 досліджуваних показників церебрального кровообігу з коефіцієнтом детермінації R2 більшим 0,6, в тому числі 5 моделей амплітудних (R2 від 0,783 до 0,868), 5 часових (R2 від 0,752 до 0,882) і 7 похідних (R2 від 0,639 до 0,888) показників реоенцефалограми. До побудованих моделей амплітудних показників реоенцефалограми найбільш часто входять обхватні розміри тіла (29,0%), поздовжні розміри тіла (22,6%), товщина шкірно-жирових складок (19,4%) і діаметри тіла (12,9%); до моделей часових показників реоенцефалограми - обхватні розміри тіла (51,6%), діаметри тіла (19,4%) і ширина дистальних епіфізів довгих трубчастих кісток кінцівок (12,9%); до моделей похідних показників реоенцефалограми - обхватні розміри тіла (27,9%), діаметри тіла (18,6%), кефалометричні показники, поздовжні розміри тіла, товщина шкірно-жирових складок та ширина дистальних епіфізів довгих трубчастих кісток кінцівок (по 11,6%).*

Ключові слова: *практично здорові жінки середнього проміжного соматотипу, церебральна гемодинаміка, антропометричні показники, регресійні моделі.*

Серебренникова О.А., Семенченко В.В., Шепитько К.В.
МОДЕЛИРОВАНИЕ ИНДИВИДУАЛЬНЫХ ПОКАЗАТЕЛЕЙ МОЗГОВОГО КРОВООБРАЩЕНИЯ В ЗАВИСИМОСТИ ОТ АНТРОПО-СОМАТОМЕТРИЧЕСКИХ ПАРАМЕТРОВ ТЕЛА ПРАКТИЧЕСКИ ЗДОРОВЫХ ЖЕНЩИН СРЕДНЕГО ПРОМЕЖУТОЧНОГО СОМАТОТИПА

Резюме. *В статье описаны и проанализированы регрессионные модели индивидуальных показателей мозгового кровообращения у практически здоровых женщин среднего промежуточного соматотипа на основе учета их антропометрических, соматотипологических показателей и показателей компонентного состава массы тела. Смоделировано 17 из 18 исследуемых показателей мозгового кровообращения с коэффициентом детерминации R2 большим 0,6, в том числе 5 моделей амплитудных (R2 от 0,783 до 0,868), 5 временных (R2 от 0,752 до 0,882) и 7 производных (R2 от 0,639 до 0,888) показателей реоэнцефалограммы. В построенные модели амплитудных показателей реоэнцефалограммы наиболее часто входят обхватные размеры тела (29,0%), продольные размеры тела (22,6%), толщина кожно-жировых складок (19,4%) и диаметры тела (12,9%); в модели временных показателей реоэнцефалограммы - обхватные размеры тела (51,6%), диаметры тела (19,4%) и ширина дистальных эпифизов длинных трубчатых костей конечностей (12,9%); в модели производных показателей реоэнцефалограммы - обхватные размеры тела (27,9%), диаметры тела (18,6%), кефалометрические показатели, продольные размеры тела, толщина кожно-жировых складок и ширина дистальных эпифизов длинных трубчатых костей конечностей (по 11,6%).*

Ключевые слова: *практически здоровые женщины среднего промежуточного соматотипа, церебральная гемодинамика, антропометрические показатели, регрессионные модели.*

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