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ESTIMATION METHODS AND RATE OF ONTOGENETICALLY DISHARMONIC FAT COMPONENT OF HUMAN BODY MASS IN VARIOUS AGE AND GENDER GROUPS

ABSTRACT

The research has been carried out within the comprehensive program of obtaining, accumulation and analysis of results using the common conventional and novel techniques. Material of research was the results of direct anthropometry of about 1300 people divided on the basis of the ontogenetic period. Anthropometric research is executed proceeding from V. V. Bunak's chart and meant definition of the general (growth, weight, body surface area), the partial sizes of a human body (longitudinal, volumetric, cross, sagittal) and a skin fat fold thickness. The saved-up results made the reference database which results of development became a basis of the statistical analysis which fragment is given in this article, as well as number of the advanced development.

In anthropometry, using the caliper on the back of the shoulder (d1, mm.) measurements were performed at lowered hand in the upper third of the arm triceps, close to its inner edge (the result is recorded on the vertical axis), under shoulder-blade (d2, mm., measurements are performed under the lower angle of the scapula, in an oblique direction: from top to bottom, inside out) and the side (d3, mm. fold, that measured above the iliac crest (the result is recorded on the vertical axis), on the front surface of the shoulder (d4, mm. it measured in the upper third of the inner surface of the upper arm biceps , in vertical direction). Mean thickness of fatty folds index was calculated using the formula: $F_1=1,14–0,06\times\log_2(d_1+d_2+d_3+d_4)$, and general thickness: $F_2=d_1+d_2+d_3$ and determine the absolute amount of fat component ($M_{ЖА}$) with formula $M_{FA}=100\times(G_0/F_1–G_1)$. Further, the evaluation performed by BMFC endomorphic index (M_{FB}), which is defined by the formula $M_{ЖТ}=G_2+G_3\times F_2–G_4\times F_2^2+G_5\times F_2^3$, considering age and sexual coefficients (G_0-G_5) and variability (SD) of an endomorphic indicator ($M_{FB}\pm SD_{FB}$) and absolute amount of fatty tissue ($M_{FA}\pm SD_{FA}$).

Results and their discussion. Using the accumulated database, programmed in Excel for each of the patients, the basis of the data of direct anthropometry calculated: index of absolute fat mass (M_{FA}) and endomorphic index (M_{FB}), which allowed determining ontogenetic harmonious relation of fat mass components body, defined relative and absolute frequencies of this phenomenon.

Analysis of these data revealed that the frequency of ontogenetic disharmony of fat component of body mass analyzed by ontogenetic periods ranged from 11,0±1,6 % to 30,0±3,0 %, averaging over all persons at 15,4±1,0 %. Among males the lowest frequency of disharmony body weight on his fat component found in the second period of childhood – is 8,4±1,8 %, and the highest – 33,3±4,4 % in the first period of adulthood. Among females the highest frequency disharmony of body weight on his fat component found in the first period of adult age – 26,7±4,1 %, whereas in previous ontogenetic periods , this figure has been relatively stable and not significantly different, depending on age.

Based on the data, elaborated analytical and numerical models (polynomials) frequency of ontogenetic disharmony of body weight due to fat component, which allows the application to objectify identified patterns and, if necessary, calculate the frequency of ontogenetic are caused chopped disharmony of body weight in fat component by gender (means of traveling power-substitution instead of X – the number you ontogenetic period).

Conclusions. On the basis of direct anthropometry the regularities of formation of human body fat at the stages of postnatal ontogenesis have been revealed, which become apparent by different rate of body mass disharmony due to its fat component, especially in comparative aspect of gender groups' ontogenesis.

The findings of generalized development of aggregated anthropometric data define the areas of development of traditional methodology of anthropometry, valid advanced methodology, in particular; provides with estimation of ontogenetically disharmonic body build due to body mass fat component.

The assessment of ontogenetic disharmony of body mass fat component is assigned to anatomy, topographic anatomy, and other clinical disciplines and can be applied to consideration of peculiarities of body build while assessing the body composition.

The findings can explain the age differences as for the rate of initiation of functional disorders, prenosological, as well as nosologically defined pathological conditions as manifestation of general process of growth and development in postnatal ontogenesis.

Key words: anatomy, anthropometry, ontogenesis, body mass fat component.

The findings, presented in the paper, have been obtained during the field anthropometric studies, provided for the interstate research scientific work, entitled «Study of structural and functional state of osseous tissue in children and adolescents, living in ecologically unfavorable regions» (2004-2006) [12, 13], during the regional population observations in compliance with the University's research scientific work program: «Validation and implementation of system of regional monitoring of children and adolescents' health in conditions of the reformation of Primary Health Care for Ukrainian population» [7] (State registration No 0107U001392) and are followed up within the initiative prospecting research scientific work, performed by the Departments of Operative Surgery and Topographic Anatomy (Prof. V. G. Dudenko, Chair of the Department) and Human Anatomy (Prof. A. O. Tereschenko, Chair of the Department) at Kharkiv National Medical University (Prof. V. M. Lisoviy, Rector, Corresponding Member of the National Academy of Medical Sciences of Ukraine).

Introduction. The human body mass fat component (BMFC) is one of the indices of human body build and the indicator of its nutritional (alimentary) status. As is generally known, BMFC may change dynamically at the stages of postnatal ontogenesis under the impact of various coefficients [5]. Decrease and increase of BMFC can be transitory or persistent, determined by the state of metabolic processes in the corresponding period of ontogenesis, regionally – by the environmental differences, rate of motion activity and state of human somatic health [4]. To estimate the body fat components in people of various ages, especially in childhood and adolescence, anthropometric indices and their derivatives are widely used. Among the latter, the most popular is the body mass index (BMI), which is used in the form of percentile scales. The most common percentile scales are developed by the CDC specialists and recommended for use in all WHO's countries. These scales were adapted to regional characteristics of physical development of children and adolescents in Russia [6]. However, percentile scales of body mass index are not used in Ukraine to date due to inadaptability to the regional characteristics of physical development. In addition, considering the certain ethnic and socio-cultural features of nutrition, the prevalence of the phenomenon of deceleration in some countries, as well as in Ukrainian regions, no percentile scales are developed to assess the BMI, which would be most adapted to national conditions. A somatotype is also known as one of the integral indices of body build, which is used to measure the relative amount of fat component of a particular individual [2, 8]. Moreover, the defined somatotype can be applied to evaluate the composition of body mass components, the absolute value of human body fat mass, in particular [3].

Materials and Methods. The research has been carried out according to the comprehensive program of obtaining, accumulation and analysis of the results, using the common conventional and novel techniques. The common way of anthropometric assessment of nutritional status, using the BMFC index [10], involves estimation of the body mass index (BMI=weight(kg)/stature^2(m)), which may be different due to additional calipermetric measurement of skinfolds at 4 standard sites: middle third of the arm above biceps, above triceps, inferior angle of scapula and right inguinal region, 2 cm higher the mid- Poupart's ligament, followed by the calculation of the index of human body fat composition according to the equations, considering the gender: D=1,1620–0,0630×(lg S) for male individuals and D=1,1549–0,50678×(log S) for female individuals, where D – index of body fat composition, S – the sum (total number) of skinfolds; afterwards, the obtained indices are compared with reference values, presented in the form of centile scales. The normal alimentary status is assumed when the value of body fat index and BMI is within the 25-75 centiles, the deficit alimentary status is observed in values less than three centiles and the excessive alimentary status of a child is stated when value of the indices is grater than 97 centiles; at the same time the ranges from 3 to 25 centiles are assumed as below the average alimentary status, whereas the range from 75 to 97 centiles is assumed as above the average alimentary status. The procedure involves children patients, where centile scales are applied, making impossible to be applied in older age groups without consideration of a somatotype and absolute amount of BMFC, as well as its individual ontogenetic variability. The conventional mode of assessment of body build includes specific chart [17], where the body build is assessed by the integral criterion, combining three components: endomorphic, mesomorphic and ectomorphic. At the same time fat component by endomorphic index is estimated according to the equation, considering the relevant coefficients, obtained in compliance with anthropometric findings. Application of this technique enables to measure endomorphic component of human

body build; however, no absolute amount of BMFC, as well as variability of this index according to age, gender and peculiarities of physical development are taken into account. Another common way of assessment of BMFC is based on the direct anthropometry with further application of specific computational algorithm [16]. The essence of abovementioned technique of anthropometric estimation of absolute amount of BMFC is in the measurement of skinfolds, made on the posterior surface of arm, below scapula and on the side, anterior surface of arm, and calculation of the mean value of thickness index (F_1) and total thickness, followed by the measurement of absolute amount of BMFC according to specific equation. This technique enables the use of direct anthropometric measurements to obtain the index of absolute amount of BMFC. However, application of the technique provides for assessment of BMFC without consideration of body build, its endomorphic index, in particular, being not complete while considering the ontogenetic features of BM components [16].

Findings of the direct anthropometry, involving over 1300 individuals, stratified according to characteristic of the ontogenetic period (Table1) served as the study material. Anthropometric study has been made according to the V. V. Bunak's chart [1] and provided for measurement of total (length, weight and calculation of body surface area), partial body sizes (longitudinal, circumferential, transversal, anteroposterior) and skinfold thickness. Aggregated results comprised the reference database [7], and processed information formed the basis for statistical analysis, fragment of which is presented in the paper, and number of advanced developments [15, 16].

Anthropometry involved measurements, using the caliper. They were made on the posterior surface of arm (d1, mm; hand down, on the upper third of arm above triceps, closer to its inner edge and measuring result was set on the vertical axis), beneath the scapula (d_2, mm; under inferior angle of scapula, cantwise: top-down, inside-out) and on the side (d_3, mm; superoiliac bone is measured over the ridge of iliac bone and measuring result was set on the vertical axis), on the anterior surface of arm (d_4, mm; is measured at the upper third of the inner surface of arm above biceps, vertically). The mean value of skinfold thickness index was calculated by the equation: $F_1=1{,}14-0{,}06\times\log_2(d_1+d_2+d_3+d_4)$, and their total thickness by: $F_2=d_1+d_2+d_3$; the absolute amount of body fat component (M_{FA}) was defined by the equation: $M_{FA}=100\times(G_0/F_1-G_1)$. Estimation of BMFC was followed by the endomorphic index (M_{FB}), calculated by the equation: $M_{FA}=G_2+G_3\times F_2-G_4\times F_2^2+G_5\times F_2^3$, taking into account the age and gender coefficients (G_0–G_5) and variability (SD) of endomorphic index ($M_{FB}\pm SD_{FB}$) and absolute amount of fatty tissue ($M_{FA}\pm SD_{FA}$) [11].

Table 1

Qualitative characteristic of reference anthropometric database aggregation

Stage of ontogenetic period	Age classification of the subjects		Anthropometry			
			Values of total body sizes	Values of partial body sizes	Values of skin folds thickness	Total number of individuals according to ontogenetic periods
VI	Late Childhood	boys 7-12 yrs.	226	226	226	400
		girls 7-11 yrs.	174	174	174	
VII	Adolescence	boys 12-16 yrs.	202	202	202	421
		girls 11-15 yrs.	219	219	219	
VIII	Youth	young boys 16-21 yrs.	156	156	156	322
		young girls 15-20 yrs.	166	166	166	
IX	Adulthood (I period)	men 21-35 yrs.	114	114	114	230
		women 20-35 yrs.	116	116	116	
Total		male	698	698	698	1372
		female	674	674	674	

The research has encompassed the common morphometric and medical statistical methods: variation statistics, probabilistic distribution of features with certainty value of results, in particular; the licensed software has been used for database maintenance and its statistical processing [14].

Results and Discussion. The outcome of application of the advanced technique [10, 11] can be demonstrated on the example: directly in the living environment during anthropometric measurements, taken for specific individual, using calibrated devices, the skinfold thickness is measured by the caliper at the posterior surface of arm (d_1, mm), beneath

the scapula (d_2), on the side (d_3), at the inferior surface of arm (d_4, mm). Afterwards, the mean value of thickness index is calculated by the equation: F_1= 1,14–0,06×$\log_2(d_1+d_2+d_3+d_4)$ and total thickness by the equation: $F_2=d_1+d_2+d_3$ and, finally, the absolute amount of body fat (M_{FA}) is determined by the equation: $M_{FA}=100\times(G_0/F_1-G_1)$, and fat component is assessed by the endomorphic index (M_{FB}), calculated by the equation: $M_{FB}=G_2+G_3\times F_2-G_4\times F_2^2+G_5\times F_2^3$, taking into account age and gender coefficients (G_0-G_5) and variability (SD) of endomorphic index ($M_{FB}\pm SD_{FB}$) and absolute amount of fatty tissue ($M_{FA}\pm SD_{FA}$). At the same time G_0-G_5 coefficients and variability (SD) of endomorphic index ($M_{FB}\pm SD_{FB}$), as well as absolute amount of fatty tissue ($M_{FA}\pm SD_{FA}$) for age and gender group, assigned to the individual, are taken from the regional reference database [7]. And if the M_{FB} of a particular child is out of the range of $M_{FB}\pm SD_{PB}$, and M_{FA} is out of the range of $M_{FA}\pm SD_{FA}$, fat component is assessed as ontogenetically disharmonic and vise versa.

Example of technique application. While performing a comprehensive medical examination of senior high school students in Kharkiv city the anthropometric measurements were taken for Ganna Yu., 15 years old, directly at school medical center; particularly, measurements were taken, using a caliper, at the posterior surface on upper third of arm, hand down, above triceps, closer to its inner edge, setting the result vertically (d_1=3,5 mm); beneath the inferior angle of scapula, cantwise: top-down, inside-out (d_2=4,2 mm) and superoiliac fold, which is higher the ridge of iliac bone (setting the result vertically; d_3=4,1 mm); at the anterior surface of arm (d_4=2,6 mm). The mean value of thickness index is calculated by the equation: F_1=1,14–0,06×$\log_2$(3,3+ 4,2+2,5+4,4) =1,07, total skinfolds thickness by the equation: $F_2=d_1+d_2+d_3$=12 mm. Age and gender coefficients, relevant to 15 year old girl, are taken from the regional database that constitute the following: G_0=4,95; G_1=4,5; G_2=-0,7182; G_3=0,1451; G_4=0,00068; G_5=0,0000014; variability of endomorphic index for corresponding age and gender constitutes $M_{FT}\pm SD_{FT}$=0,85±0,16, whereas for absolute amount of fatty tissue it is $M_{FA}\pm SD_{FA}$=12,3±1,2 uts. Absolute amount of body fat for Ganna Yu. is determined by the equation: $M_{FA}=100\times(G_0/F_1-G_1)$= 100×(4,95/1,07–4,5)=12,4, fat component for the girl is estimated by the endomorphic index by the equation $M_{FB}=G_2+G_3\times F_2-G_4\times F_2^2+G_5\times F_2$= -0,7182+ 0,1451×12–0,00068×12^2+0,0000014×12^3=1,23. Since the MFB index of Ganna Yu. is out of the range of average-group values for corresponding age and gender group (1,23>0,85±0,16), and the M_{FA} index is within the range of $M_{FA}\pm SD_{FA}$, BMFC has been estimated as ontogenetically disharmonic.

Similar to abovementioned example, using the aggregated database, the following indices have been calculated for each examinee in the EXCEL software, on the basis of their direct anthropometry: index of absolute mass of fatty tissue (MFA) and endomorphic index (MFB), providing with conclusion as for ontogenetic disharmony of body mass fat component; relative and absolute indices of the rate of such phenomenon have been defined (Table 2).

Table 2

Rate of ontogenetically disharmonic fat component of human body mass in age and gender groups

Stage of ontogenetic period	Age classification of the subjects		Number of examined	Have disharmonic fat component of body mass	
				Individuals	P±m, %
VI	Late Childhood	boys 7-12 yrs.	226	19	8,4±1,8
		girls 7-11 yrs.	174	25	14,4±2,7
		total	400	44	11,0±1,6
VII	Adolescence	boys 12-16 yrs.	202	23	11,4±2,2
		girls 11-15 yrs.	219	26	11,9±2,2
		total	421	59	14,0±1,7
VIII	Youth	young boys 16-21 yrs.	156	26	16,7±3,0
		young girls 15-20 yrs.	166	23	13,9±2,7
		total	322	49	15,2±2,0
IX	Adulthood (I period)	men 21-35 p.	114	38	33,3±4,4[c]
		women 20-35 p.	116	31	26,7±4,1[c]
		total	230	69	30,0±3,0[c]
Total		male	698	106	15,2±1,4
		female	674	105	15,6±1,4
		total	1372	211	15,4±1,0

Note: [c] – reliably differs from the corresponding index of the previous ontogenetic group.

The data analysis has shown that the rate of ontogenetically disharmonic body mass fat component at the investigated ontogenetic periods varied within 11,0±1,6 % to 30,0±3,0 %, constituting on the average of 15,4±1,0 % of all examined people. Among male individuals the least rate of body mass fat component disharmony has been noted in the period of late childhood, accounting for 8,4±1,8 %, and the highest rate (33,3±4,4%) has been noted in the first period of adulthood. Among female individuals the highest rate of body mass fat component disharmony has been noted in the first period of adulthood (26,7±4,1 %), whereas in the previous ontogenetic periods this index was relatively persistent and reliably the same according to age.

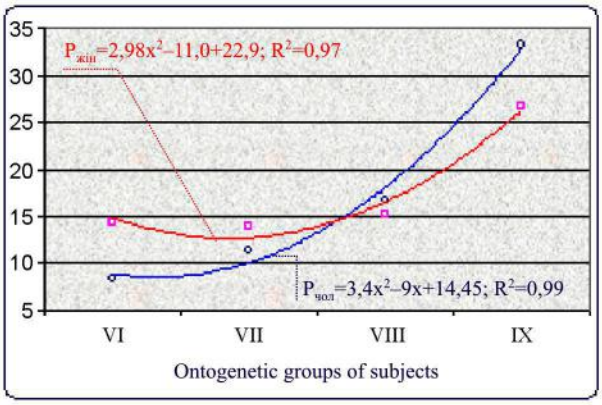

Fig. 1. Rate (Y, %) of disharmonic impairments of fat component of human body mass according to the period of ontogenesis (X)

The obtained data provided with working-out of analytical and quantitative models (polynomials) of the rate of ontogenetically-induced disharmony of body mass fat component (Fig. 1), application of which provides with objective assessment of revealed regularities and, if necessary, calculation of the rate of ontogenetically-induced disharmony of body mass fat component according to the gender (substituting the appropriate stage of ontogenetic period instead of X).

Conclusions.

1. On the basis of direct anthropometry the regularities of formation of human body fat at the stages of postnatal ontogenesis have been revealed, which become apparent by different rate of body mass disharmony due to its fat component, especially in comparative aspect of gender groups' ontogenesis.

2. The findings of generalized development of aggregated anthropometric data define the areas of development of traditional methodology of anthropometry, valid advanced methodology, in particular; provides with estimation of ontogenetically disharmonic body build due to body mass fat component.

3. The assessment of ontogenetic disharmony of body mass fat component is assigned to anatomy, topographic anatomy, and other clinical disciplines and can be applied to consideration of peculiarities of body build while assessing the body composition.

4. The findings can explain the age differences as for the rate of initiation of functional disorders, prenosological, as well as nosologically defined pathological conditions as manifestation of general process of growth and development in postnatal ontogenesis.

The perspective researches encompass the study of specific contribution of body mass muscle, fat and bone components at the stages of human postnatal ontogenesis, aiming at identification of general regularities that are significant for anatomical validation, development and enhancement of diagnostic techniques and prevention of human diseases [9].

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ТҮЙІН

Тікелей адам өлшемдерінің нәтижелері негізінде, ең алдымен онтогенезде жыныстық топтарды салыстыру кезінде оның майлы компоненттері есебінен дене салмағының әртүрлі үйлесімсіз жиілігімен көрінетін постнатальді онтогенез сатыларындағы адамның дене салмағының майлы компоненттерін қалыптастыру заңдылығы анықталған. Қол жеткізген қорытындылар бойынша функционалдық және нозологияға дейінгі бұзылыстардың қалыптасу жиілігінде, сондай-ақ өсудің жалпы үдерістерінің көрінісі мен постнатальді онтогенездегі даму ретінде нозологиялық сипатталатын жағдайлардың жастық ерекшелігімен түсіндіруге болады.

Түйінді сөздер: анатомия, антропометрия, онтогенез, дене салмағының майлы компоненті.

АННОТАЦИЯ

На основе результатов прямой антропометрии выявлены закономерности формирования жировой компоненты массы тела человека на этапах постнатального онтогенеза, которые проявляются разной частотой дисгармоничности массы тела за счёт жировой его компоненты, в первую очередь при сравнении в онтогенезе половых групп. Полученными результатами можно объяснить возрастные отличия в частоте формирования функциональных и донозологических расстройств, а также нозологически очерченных состояний, как проявлений общего процесса роста и розвития в постнатальном онтогенезе.

Ключевые слова: анатомия, антропометрия, онтогенез, жировая компонента массы тела.