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Disharmony of Human Body Composition in Gender Groups of Late Childhood Period

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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" (2006-2008 p.) [13, 14, 20], 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" [8, 19] (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) and Human Anatomy (Prof. A.O. Tereschenko) at Kharkiv National Medical University (Prof. V.M. Lisoviy, Rector, Corresponding Member of the National Academy of Medical Sciences of Ukraine).

Introduction. Bunak V.V. stated that the level of physical development of human individual is determined by the overall body size and absolute value of its mass [1]. Determination of regularities in the process of body growth and formation is one of the important tasks in the study of ontogenetic development [1, 4. 6, 7, 18]. It is also known that body somatotype is one of the integral indices of its build, which is used for assessment of relative human body mass composition of particular individual [2, 4, 9]. The human body mass fat component (BMFC) is one of the indices of human body build and the indicator of its nutritional (alimentary) status that can be changed dynamically under the impact of various factors [4, 6, 9, 23]. The human body mass muscle component (BMMC) is one of the indices of body build and indicator of its structural and functional state at the stages of ontogenesis [15-17]. Changes of BMMC can be transient or persistent that is determined by the state of metabolic processes in the corresponding period of ontogenesis, alimentary supply of nutritional homeostasis, regimen of movement activity and state of human somatic health [5, 15, 16, 22]. Generally, osteogenesis, initiating in the antenatal period, lasts for 25-30 yrs, and age changes of bone component are the most apparent at the initial stage of postnatal ontogenesis [4, 9, 21]. Change in bone mass can be transient or persistent that is determined by the state of metabolic processes in the corresponding period of ontogenesis, regionally – by ecological differences, alimentary supply of nutritional homeostasis, regimen of movement activity, state of somatic health and human somatotype [13, 14, 19-23].

Asynchronous processes in body mass and build formation occur in the ontogenetic period of late childhood; it is in this period when the bony skeleton is formed with progressive dynamics of bone mass accumulation [9, 13, 14, 19, 20].

The research was aimed at comparative study of indices of human body build and composition in the ontogenetic period of late childhood.

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 approaches. Findings of the direct anthropometry, data of dynamometry and ultrasound bone densitometry of representative number of individuals, stratified according to characteristic of the ontogenetic period, age and gender **(Table1)** served as the study material. Anthropometry has been studied according to the V.V. Bunak's chart [1] and provided for measurement of total, partial body sizes and skinfold thickness. Aggregated results comprised the reference database [8], and processed information formed the basis for statistical analysis (its fragment is presented in the paper, as well as other publications [8-14, 21-23]) and were the ground for development of number of approaches to assessment of the results of anthropometry [10-12]. On the basis of age periodization of ontogenetic periods, boys, aged 7-12 years and girls, aged 7-11 years have been assigned to ontogenetic period of late childhood [4, 6, 7, 18].

The procedure of BMFC estimation [10] included measurement of skinfold thickness, using caliper, taken at the posterior surface of arm (d1, mm), beneath the scapula (d2), on the side (d3), on the anterior surface of arm (d4, mm). Thereafter the mean value of thickness index was calculated by the equation: $F1 = 1{,}14 - 0{,}06 \times \log 2(d1 + d2 + d3 + d4)$ and total thickness by

Table 1

Quantitative characteristic of reference anthropometric database aggregation (anthropometry, dynamometry, bone densitometry)

Subjects' gender	Age periodization of subjects	Anthropometry				Dynamometry		Ultraviolet densitometry (calcaneus) [8, 19, 20]
		direct	Body mass components			hand	stature	
			fat	muscle	bone			
Male individuals	7 yrs	28	28	28	28	-	-	-
	8 yrs	32	32	32	32	-	-	-
	9 yrs	45	45	45	45	35	35	32
	10 yrs	44	44	44	44	37	37	34
	11 yrs	36	36	36	36	33	33	31
	12 yrs	31	31	31	31	30	30	28
Female individuals	7 yrs	31	31	31	31	-	-	-
	8 yrs	35	35	35	35	-	-	-
	9 yrs	34	34	34	34	32	32	30
	10 yrs	36	36	36	36	34	34	34
	11 yrs	38	38	38	38	33	33	33
Total	male	226				162		125
	female	174				99		97
	total	400				261		222

the equation: F2=d1+d2+d3; finally the absolute amount of body fat component (MFA) was defined by the equation: MFA=100Ч (G0/F1-G1) and fat component was assessed by the endomorphic index (MFT), calculated by the equation: MFA= G2+G3ЧF2 - G4ЧF22 +G5ЧF23, accounting for the age and gender coefficients (G0-G5) and variability (SD) of endomorphic index (MFB± SDFB) and absolute amount of fatty tissue (MFA± SDFA). At the same time G0-G5 coefficients and variability (SD), as well as endomorphic index (MFT± SDFT) for the age-and-gender group, assigned for particular individual, were taken from the regional reference database [8].

Estimation of BMMC [11] encompassed width of distal epiphyses of arm (F1, cm) and hip (F2, cm), measured by the caliper to the nearest 0,01 cm; shoulder circumference (F3, cm) in its stressed state was measured by measuring tape to the nearest 0,5 cm, followed up with determining the arm muscular tissue area (F4, cm2); shin circumferential parameters (F5, cm) were measured by measuring tape to the nearest 0,5 cm and human stature (F6, cm) was measured by versatile anthropometer to the nearest 0,5 cm; finally absolute body muscle mass (MMA) was calculated by the equation MMA= F6Ч(X0+X1ЧF4), and muscle component was estimated by the mesomorphic index (MMT), calculated by the equation: MMT= (X2ЧF1+ X3ЧF2 + X4ЧF3 +X5ЧF5)-X6ЧF6+X7). At the same time (X0-X7) gender coefficients, appropriate for corresponding ontogenetic period, and variability (SD) of mesomorphic index (MMT± SDMT), as well as absolute amount of muscular tissue (MMA±SDMA) in the particular group were taken from the reference database [8].

Estimation of body mass bone component (BMBC) [12] encompassed body height (H, cm), measured by versatile anthropometer to the nearest 0,1 cm, and body mass (BM, kg) was measured using balance scale to the nearest 0,1 kg. Width of distal epiphyses of arm (s1, cm), forearm, forearm width (s2, cm), hip width (s3, cm) and shin width (s4, cm) was measured by sliding caliper to the nearest 0,01 cm. Ones anthropometry was finished the height-and-weight index was calculated for particular individual by the equation: (IMT=H/MB-3); mean value of circumferential parameters was calculated by the equation: $\delta=(s1+s2+s3+s4)/4$; absolute bone tissue mass (MBA, kg) was calculated by the equation: MBA = $\delta^2 \times H \times 1{,}2 / 1000$, and ectomorphic index (MBT) was calculated by the equation: MBT= IMTЧX1-X2. At the same time X1 and X2 coefficients and variability (SD) of ectomorphic index (MBT± SDBT), as well as absolute amount of bone tissue (MBA± SDBA) for age -and -gender group, assigned to particular individual were taken from the reference database [8].

Results and Discussion. Gender differences related to the rate of ontogenetically disharmonic BMMC are not found, though the rate of male individuals was somewhat higher the relevant index among female individuals 14,6±2,3% and 9,2±2,3%, respectively; p>0,05). The rate of ontogenetically disharmonic BMFC in gender groups varied within 8,4±1,8% to 14,4±2,7% **(Table 2)**, constituting on the average of 11,0±1,6% of all examined people, indicating about reliably higher rate of disharmony by this body mass component among girls (p<0,05).

Table 2

Rate of ontogenetically disharmonic body mass composition in gender groups of late childhood period

Subjects' age periodization		P±m,% of individuals with disharmonic body mass composition		
		muscle	fat	bone
late childhood period	boys 7-12 yrs.	14,6±2,3	8,4±1,8	17,3±2,5[a]
	girls 7-11 yrs.	9,2±2,3	14,4±2,7[б]	8,0±2,1
	total	12,3±1,6	11,0±1,6	13,2±1,7

Note: [a] – in one ontogenetic group – reliably more frequently among male individuals; [б] – in one ontogenetic group – reliably more frequently among female individuals.

The rate of ontogenetically disharmonic BMBC is reliably (p<0,001) higher among male individuals. In the late childhood period the rate of ontogenetically disharmonic BMBC in female individuals accounted for 8,0±2,1%, whereas it was reliably and significantly higher (2 times) among male (17,3±2,5%).

The regularities of rising of bone tissue density index (BTDI) in girls have been analyzed among children of different age groups; in the process of growth and development the BTDI varies within 85,5±0,9 to 103,6±2,0. This tendency is reflected rather accurately (R2=0,980) by statistical dependence between the girls' BTDI and age, presented in the form of Stage IV polynomial: BTDI = 0,015x4 - 0,26x3 + 1,6x2 - 1,8x + 80,7, where x – girls' age in years. For comparison, it should be noted that the growth of girls' body mass occurs with similar annual growth rate and is characterized by the following regularity (statistical model with the accuracy of R2 = 0,991): BM = 0,013x4 - 0,39x3 + 3,57x2 - 9,2x + 43,3 (kg).

Relationship between girls' BTDI and height-and-weight index is characterized by the periods of BTDI growth, demonstrating in favor of the uneven pace of bone mass accumulation. For a comprehensive assessment and consideration of the influence of height and body mass on bone density we suggested and calculated a standardized index – somatometric gradient of bone tissue density of girls of different age, which determines the maximum bone mass indices in the period of late childhood. Study of the relationship between the indicators of girls' physical development and indicators of the bone tissue state revealed that BTDI is characterized by a strong direct correlation between the height indices (rXY = + 0,985), body mass (KDI; rXY = + 0,984) and HC (rXY = + 0,978).

The regularities of rising of BTDI in boys varies within 84,8±1,3 to 107,7±2,1. This tendency is reflected rather accurately (R2=0,88) by statistical dependence between the boys' BTDI and age, presented in the form of polynomial BTDI = -0,062x4 + 1,29x3 - 9,42x2 + 29,5x + 64,5, where x – boys' age in years. For comparison, it should be noted that the growth of boys' body mass occurs with higher annual growth rate and is characterized by the following statistical regularity (statistical model with the accuracy of R2 = 0,991): BM = -0,043x4 + 0,71x3 - 3,55x2 + 10,2x + 23,9 (kg). Analysis of correlation between the indicators of boys' physical development and indicators of the bone tissue state concluded that BTDI is characterized by a strong direct correlation between the indices of stature dynamometry (SDM; rXY=+0,905), hand dynamometry (KDI; rXY=+0,903) and boys' height (rXY=+0,901) **(Table 3)**.

Table 3

Somatometric, morphofunctional and densitometric indices according to subjects' age and gender

Age, years	Groups	Somatometric indices and densitometric index					Dynamometry (hand and stature)			Ultrasound densitometry (calcaneus)	
		weight	height	CC	HC	BTDI	right	left	stature	SOA	SOS
		(M±m) кг	(L±m) см	(T±m) см	(C±m) см	IM±m	(F_1±m) кг	(F_2±m) кг	(F_3±m) кг	(S±m) м/с	(S_t±m) дБ/МГц
9 yrs.	girls	31,6±0,5	138,3±0,7	51,6±0,2	63,2±0,3	85,5±0,9	10,2±0,5	10,0±0,5	28,1±0,7	1552,5±1,9	45,8±2,0
	boys	31,3±0,6	136,0±0,6	52,9±0,2	66,8±0,8	84,8±1,3	10,9±0,7	9,7±0,6	29,0±1,1	1552,8±1,5	48,4±2,5
10 yrs.	girls	36,8±0,8	142,6±0,8	52,9±0,2	68,4±0,8	86,7±1,1	13,2±0,6	11,7±0,6	38,7±0,9	1546,5±2,1	51,3±2,4
	boys	35,1±0,8	144,1±0,8	53,3±0,2	66,7±0,7	98,9±1,0	17,1±0,6	16,3±0,5	49,0±1,7	1565,3±2,3	53,5±2,6
11 yrs.	girls	40,0±1,0	147,6±0,9	53,5±0,2	71,8±0,8	91,7±1,5	14,6±0,6	13,5±0,5	39,6±1,6	1549,5±2,7	54,9±2,3
	boys	37,7±0,9	145,7±0,8	53,8±0,1	69,0±0,7	93,4±1,3	19,3±0,5	17,5±0,5	55,4±1,4	1563,4±3,7	56,9±2,6
12 yrs.	boys	43,3±1,1	154,0±1,1	54,2±0,2	73,3±0,8	99,7±1,4	21,7±0,8	19,9±0,7	64,5±2,2	1565,4±3,1	66,7±2,6

Note: BTDI – bone tissue density index , BM – body mass, HC – head circumference, CC – chest circumference, SOS – speed of sound in the heel; SOA – speed of ultrasonic attenuation.

The concept of ontogenetic transitivity of osteopenic impairments in the process of growth and development in childhood assumed the physiological nature of reduction of bone mass in girls with its minimum at 11 years old, and, simultaneously, reduction of the rate of disharmonic variants of body mass by its bone component (Table 2). Analysis of the factors of spatial-trabecular organization in girls, according to densitometry, showed that the BT density and bone mass is determined primarily by the membranous component of the bone, and the accumulation of bone mass in girls is a derivative of the process of accumulation of minerals mainly in membrane area of tubular bones. At the same time, reduction of the somatometric gradient of density at the age of 11 indicates in favor of relative reduction of mineralization of proper bone tissue.

Conclusions.

1. On the basis of direct anthropometry the regularities of formation of body mass composition in the period of late childhood have been established, which become apparent by different rate of disharmonic types, 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 techniques, in particular; provides with estimation of ontogenetically disharmonic body build due to body mass components with specification of its bone component.

3. The assessment of ontogenetic disharmony of body mass bone, muscle and fat components, related to some morphofunctional indices has revealed correlation relationships.

4. The findings can explain the age differences related to 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, defining the research guidelines in the field of clinical and human topographic anatomy.

Perspectives of further research encompass determination of structural ratios of linear and mass-volumetric indices of human body at the subsequent stages of postnatal ontogenesis.

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ДИСГАРМОНІЙНІСТЬ КОМПОНЕНТНОГО СКЛАДУ МАСИ ТІЛА ЛЮДИНИ У СТАТЕВИХ ГРУПАХ ПЕРІОДУ ДРУГОГО ДИТИНСТВА

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Резюме. На основі прямої антропометрії виявлені закономірності формування компонентного складу маси тіла в в періоді другого дитинства, що проявляються різною частотою дисгармонійних типів, насамперед у порівняльному аспекті онтогенезу статевих груп. За результатами узагальненої розробки накопичених антропометричних даних визначено напрямки розвитку класичної методології антропометрії, зокрема і інноваційних методик, забезпечено визначення онтогентично дисгармонійної тілобудови за рахунок компонентів маси тіла з деталізацією кісткової компонети.

Ключові слова: анатомія, антропометрія, онтогенез, компоненти маси тіла, тілобудова.

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ДИСГАРМОНИЧНОСТЬ КОМПОНЕНТНОГО СОСТАВА МАССЫ ТЕЛА ЧЕЛОВЕКА В ПОЛОВЫХ ГРУППАХ ПЕРИОДА ВТОРОГО ДЕТСТВА

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Резюме. На основе прямой антропометрии выявлены закономерности формирования компонентного состава массы тела, которые проявляются разной частотой дисгармоничных типов в разных половых группах. Определены направления развития классической методологии антропометрии, в частности за счёт инновационных разработок, обеспечивающих определение онтогентически дисгармоничное строение тела за счёт компонентов его массы, с отдельной детализацией костной компоненты.

Ключевые слова: анатомия, антропометрия, онтогенез, костная компонента массы тела, строение тела.

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DISHARMONY of HUMAN BODY COMPOSITION IN GENDER GROUPS OF LATE CHILDHOOD PERIOD

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Abstract. The research was aimed at comparative study of indices of human body build and composition in the ontogenetic period of late childhood. *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 approaches. Findings of the direct anthropometry, data of dynamometry and ultrasound bone densitometry of representative number of individuals, stratified according to characteristic of the ontogenetic period, age and gender served as the study material.

Gender differences related to the rate of ontogenetically disharmonic BMMC are not found, though the rate of male individuals was somewhat higher the relevant index among female individuals 14,6±2,3% and 9,2±2,3%, respectively; $p>0,05$). The rate of ontogenetically disharmonic BMFC in gender groups varied within 8,4±1,8% to 14,4±2,7%, constituting on the average of 11,0±1,6% of all examined people, indicating about reliably higher rate of disharmony by this body mass component among girls ($p<0,05$).

The concept of ontogenetic transitivity of osteopenic impairments in the process of growth and development in childhood assumed the physiological nature of reduction of bone mass in girls with its minimum at 11 years old, and, simultaneously, reduction of the rate of disharmonic variants of body mass by its bone component. Analysis of the factors of spatial-trabecular organization in girls, according to densitometry, showed that the BT density and bone mass is determined primarily by the membranous component of the bone, and the accumulation of bone mass in girls is a derivative of the process of accumulation of minerals mainly in membrane area of tubular bones. At the same time, reduction of the somatometric gradient of density at the age of 11 indicates in favor of relative reduction of mineralization of proper bone tissue. The rate of ontogenetically disharmonic BMBC is reliably ($p<0,001$) higher among male individuals. In the late childhood period the rate of ontogenetically disharmonic BMBC in female individuals accounted for 8,0±2,1%, whereas it was reliably and significantly higher (2 times) among male (17,3±2,5%).

Conclusions. On the basis of direct anthropometry the regularities of formation of body mass composition in the period of late childhood have been established, which become apparent by different rate of disharmonic types, 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 techniques, in particular; provides with estimation of ontogenetically disharmonic body build due to body mass components with specification of its bone component. The assessment of ontogenetic disharmony of body mass bone, muscle and fat components, related to some morphofunctional indices has revealed correlation relationships.

The findings can explain the age differences related to 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, defining the research guidelines in the field of clinical and human topographic anatomy.

Keywords: anatomy, anthropometry, ontogenesis, body mass bone component, body build.

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