UDC 611.01(575.3-25)+616-071.2+572.02/.5
DOI: 10.56871/RBR.2025.33.54.002

SOMATOTYPE PROFILE OF YOUNG MEN LIVING IN DIFFERENT REGIONS OF THE REPUBLIC OF TAJIKISTAN

© Valerii O. Erkudov[1], Lojuvar M. Rustamova[2], Muhiddin S. Tabarov[2], Andrey P. Pugovkin[3]

[1] Saint Petersburg State Pediatric Medical University. 2 Lithuania, Saint Petersburg 194100 Russian Federation
[2] Avicenna Tajik State Medical University. 29–31 Sino str., Dushanbe 34003 Republic of Tajikistan
[3] Saint Petersburg Electrotechnical University. 5 Professor Popov str., Saint Petersburg 197022 Russian Federation

Contact information: Valery O. Erkudov — Candidate of Medical Sciences, Associate Professor, Associate Professor of the Department of Normal Physiology. E-mail: verkudov@gmail.com ORCID: https://orcid.org/0000-0001-7351-0405 SPIN: 5155-2173

For citation: Erkudov VO, Rustamova LM, Tabarov MS, Pugovkin AP. Somatotype profile of young men living in different regions of the Republic of Tajikistan. Russian Biomedical Research. 2025;10(1):16–30. DOI: https://doi.org/10.56871/RBR.2025.33.54.002

Received: 14.01.2025 **Revised: 28.02.2025** **Accepted: 09.04.2025**

Abstract. ***Introduction.*** Determination of somatotype opens up the possibility of creating approaches to personalized monitoring of health status of various population groups. The aim of this work is a comparative analysis and determination of prevalence of ecto-, meso- and endomorphic somatotypes in residents of regions of Tajikistan with different environmental conditions. ***Materials and methods.*** The study involved 701 male volunteers aged 19 to 22 years, 400 subjects lived in Dushanbe, 301 students — in Gorno-Badakhshan Autonomous Oblast (GBAO). Somatotyping was carried out using the Heath–Carter method. All volunteers were determined by body length and weight, knee and elbow breadth, shoulder and calf circumference, triceps, subscapular, suprailiac, calf skinfolds were measured. Based on the measured anthropometric parameters, the ecto-, meso- and endomorphic components of the somatotype were calculated using a Heath–Carter formula. The obtained data were compared using the Mann–Whitney U-test and the Pearson χ^2 test. ***Results.*** Young men who have lived in Dushanbe since birth surpass their peers from GBAO in having greater body length and weight, massive bones determined by the breadth of large joints, and the thickness of the skinfat folds. 72% of the capital's residents had a high contribution of endomorphic and a low contribution of meso- (4%) and ectomorphic (2%) components of the somatotype. Subjects from GBAO were distinguished by a high contribution of meso- (36%), ectomorphic (15%), and endomorphic (16%) body types. Overweight was determined in 35% of volunteers from Dushanbe and only 2% of subjects from GBAO. Underweight was detected in only 11% of volunteers from Dushanbe and 61% of subjects from GBAO. ***Conclusions.*** The anthropometric profile and constitutional diversity of young male residents of the Republic of Tajikistan depends on the region of their permanent residence and environmental conditions.

Keywords: anthropometric profile, somatotype, Heath–Carter, Tajikistan, Dushanbe, Gorno-Badakhshan Autonomous Oblast

DOI: 10.56871/RBR.2025.33.54.002

ПРОФИЛЬ СОМАТОТИПА У МОЛОДЫХ МУЖЧИН, ПРОЖИВАЮЩИХ В РАЗЛИЧНЫХ РЕГИОНАХ РЕСПУБЛИКИ ТАДЖИКИСТАН

© Валерий Олегович Еркудов[1], Лоджувар Мамадербековна Рустамова[2], Мухиддин Сафарович Табаров[2], Андрей Петрович Пуговкин[3]

[1] Санкт-Петербургский государственный педиатрический медицинский университет. 194100, г. Санкт-Петербург, ул. Литовская, д. 2, Российская Федерация
[2] Таджикский государственный медицинский университет им. Абуали ибни Сино. 34003, г. Душанбе, ул. Сино, д. 29–31, Республика Таджикистан
[3] Санкт-Петербургский государственный электротехнический университет. 197022, г. Санкт-Петербург, ул. Профессора Попова, д. 5, Российская Федерация

Контактная информация: Валерий Олегович Еркудов — к.м.н., доцент, доцент кафедры нормальной физиологии.
E-mail: verkudov@gmail.com ORCID: https://orcid.org/0000-0001-7351-0405 SPIN: 5155-2173

Для цитирования: Еркудов В.О., Рустамова Л.М., Табаров М.С., Пуговкин А.П. Профиль соматотипа у молодых мужчин, проживающих в различных регионах Республики Таджикистан. Российские биомедицинские исследования. 2025;10(1):16–30. DOI: https://doi.org/10.56871/RBR.2025.33.54.002

Поступила: 14.01.2025 **Одобрена: 28.02.2025** **Принята к печати: 09.04.2025**

Резюме. ***Введение.*** Определение типа телосложения открывает возможность создания подходов к персонифицированному мониторингу состояния здоровья различных групп населения. ***Цель работы*** — провести сравнительный анализ и определить распространенность экзо-, мезо- и эндоморфных соматотипов у жителей регионов Таджикистана с различными условиями окружающей среды. ***Материалы и методы.*** В исследовании приняли участие 701 мужчина-доброволец в возрасте от 19 до 22 лет, 400 субъектов проживали в г. Душанбе, 301 студент — в Горно-Бадахшанской автономной области (ГБАО). Для определения соматотипа по методу Хит–Картер всем добровольцам измеряли длину и массу тела, ширину колена и локтя, окружность плеча и голени и кожно-жировые складки на плече, спине, животе, голени. На основании этих антропометрических параметров производили расчет экто-, мезо- и эндоморфного компонента соматотипа, используя общеизвестную формулу. Для сравнения полученных данных использовали U-критерий Манна–Уитни и тест χ^2 Пирсона. ***Результаты.*** Молодые мужчины, с рождения проживающие в г. Душанбе, превосходят своих сверстников из ГБАО, имеют бóльшую длину и массу тела, массивность костей, определяемую по ширине крупных суставов, толщину кожно-жировой складки. У 72% жителей столицы имел место высокий вклад эндоморфного и низкий — мезо- (4%) и эктоморфного (2%) компонентов соматотипа. Субъекты из ГБАО отличались высоким вкладом мезо- (36%), экто- (15%) и эндоморфного (16%) типов телосложения. У 35% добровольцев из Душанбе и всего у 2% испытуемых из ГБАО определен избыток массы тела. Дефицит массы тела выявлен всего у 11% добровольцев из Душанбе и у 61% испытуемых из ГБАО. ***Выводы.*** Антропометрический профиль и конституциональное разнообразие молодых мужчин — жителей Республики Таджикистан зависит от региона их постоянного проживания и условий окружающей среды.

Ключевые слова: антропометрический профиль, соматотип, Хит–Картер, Таджикистан, Душанбе, Горно-Бадахшанская автономная область

INTRODUCTION

Body type is a stable anthropometric indicator in adults associated with muscle strength and endurance [1–4], motor skills [5, 6], and athletic performance [7, 8] in both athletes of various specializations and non-athletes. Assessment of somatotypes is used in the complex evaluation of anthropometric features, their connection with motor skills and muscle work in children [9, 10]. A candidate's belonging to the "dominant" somatotype in a given sport increases the chance of being selected for elite teams [4, 11]. Body type may be a predictor both of insufficient weight [12, 13] and obesity [14–19], and also outcome of different diseases [20–23]. Moreover, body type can be related to some morphological and functional features of the body, for example, to the size of organs [12, 15], blood cell content [24–26], vegetative status [27, 28]. Information about the constitutional characteristics of patients helps in the implementation of approaches to organizing proper nutrition [29] and prescribing adaptive physical education programs [30].

Due to the above, including differentiation of body types in objective examination of healthy athletes, children and adults, and also sick people gives up the possibility of implementing approaches to personalized monitoring of their health. The scientific literature has documented population studies to determine the prevalence of somatotypes in Russian [15, 31–33], Polish [34], Portuguese [35], Chinese [18, 36], Korean [37], Japanese [19], and Chilean [38] cohorts. At the same time, there is a lack of studies involving subjects from Central Asia. There is a limited number of publications describing the constitutional characteristics of residents of Uzbekistan [39–41], Kazakhstan [42], Kyrgyzstan [43, 44], and Tajikistan [45–47].

AIM

The aim of the study is to conduct a comparative analysis and determine the prevalence of exo-, meso- and endomorphic somatotypes determined by the Heath–Carter method in residents of two regions of Tajikistan with different environmental conditions: Dushanbe and the Gorno-Badakhshan Autonomous Region (GBAO). This work is necessary to expand our understanding of the constitutional characteristics of residents of Central Asia.

MATERIALS AND METHODS

The study included data on 701 healthy men aged 19–22 years. All of them were students of the Tajik State Medical University named after Abu Ali Ibni Sino. Of these,

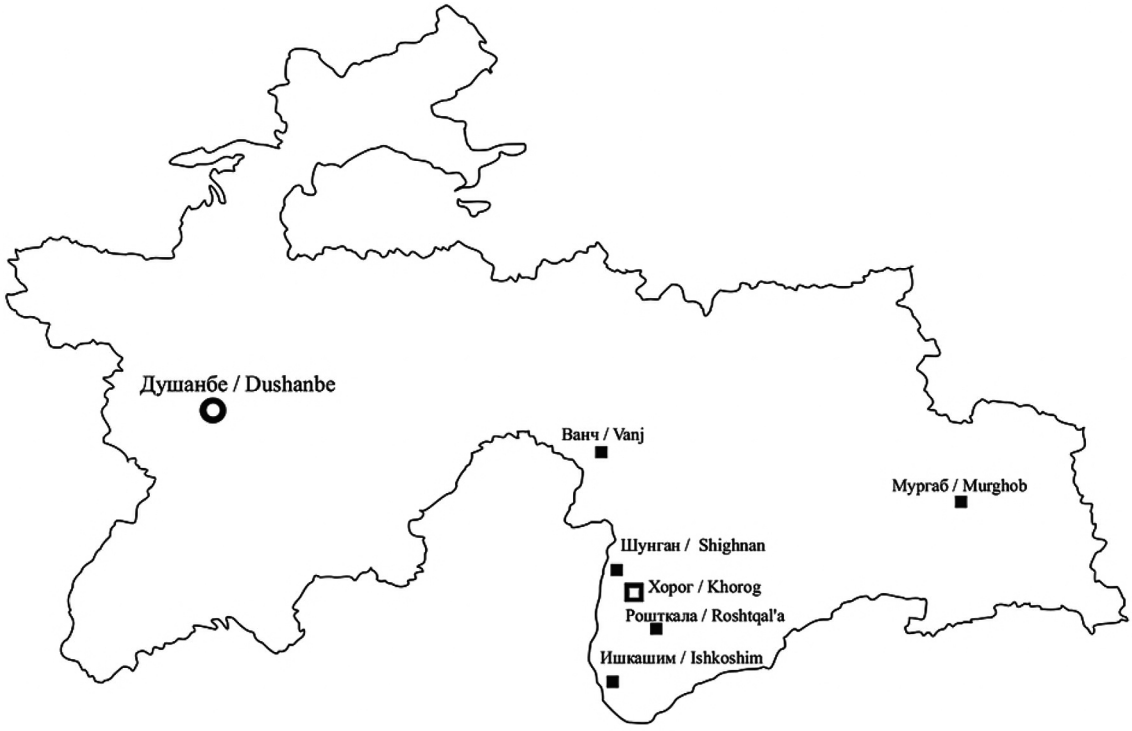


Fig. 1. Study area. ○ — capital of the Republic of Tajikistan; □ — administrative center of Gorno-Badakhshan Autonomous Oblast; ■ — settlements of Gorno-Badakhshan Autonomous Oblast

Рис. 1. Область исследования. ○ — столица Республики Таджикистан; □ — административный центр Горно-Бадахшанской автономной области; ■ — населенные пункты Горно-Бадахшанской автономной области

400 subjects lived in Dushanbe, the capital of the republic, from birth, and 301 students lived in the Gorno-Badakhshan Autonomous Region (GBAO): the villages of Vanch, Ishkashim, Roshtkala, Shugnan, Murghab, and the city of Khorog (Fig. 1). To assess somatotype due to the Heath–Carter method, the subjects had their apical body length (ABL) measured using a medical stadiometer MP-01/S (Moscow Weighing Plant MIDL), and their body mass (BM) measured using medical scales VMEN-150-50/100-I-D1-A (JSC Tulinovsky Instrument-Making Plant TVES). Also, the knee width (KW) and elbow width (EW) were measured using a sliding caliper ("KAFA", Russia). A non-elastic ergonomic tape measure (SECA 203, Germany) was used to measure the upper arm circumference (UA) and lower leg circumference (LLC) with an accuracy of 0.01 cm. The thickness of the skin-fat folds (SFF) was measured using a professional caliper ET MEASURE model SK-101 (China), with a spring calibrated to create the same pressure (0.01 kg/mm^2) on both sides of the fold, the measurement accuracy was 0.2 mm. SFF was measured in four places: on the back of the shoulder in the triceps area (SFF triceps), on the back in the scapula area (SFF back), on the abdomen above the iliac crest (SFF supraspinatus) and on the back of the shin (SFF shin). All anthropometric measurements were made according to modern recommendations [48].

In 1960, Barbara Heath and Lindsay Carter proposed an approach based on a series of equations requiring the above measurements of anthropometric parameters, which allows calculating the degree of expression of the ectomorphic (ECTO (1)), mesomorphic (MESO (2)) and endomorphic (ENDO (3)) components in the somatotype of a particular subject [49].

$$\text{ECTO (BL/BM, body length/body weight ratio)} = \frac{\text{BL, sm}}{\sqrt[3]{\text{BM, kg}}}; \quad (1)$$

If BL/BM ≥40,75, so ECTO = 0,732 · BL/BM – 28,58.

If BL/BM 38,25 to 40,75, so ECTO = = 0,463 · BL/BM – 17,63.

If BL/BM ≤38,25, so ECTO = 0,5.

$$\text{MESO} = (0{,}858 \cdot \text{EW, cm} + 0{,}601 \cdot \text{KW, cm} + 0{,}188 \cdot (\text{UA, cm} - \frac{\text{SFF triceps, mm}}{10}) + 0{,}161 \cdot (\text{CC, cm} - \frac{\text{SFF shin, mm}}{10}) - (0{,}131 \cdot \text{BL, cm}) + 4{,}5; \quad (2)$$

$$\text{ENDO} = -0{,}7182 + 0{,}1451 \cdot X - 0{,}00068 \cdot X^2 + 0{,}0000014 \cdot X^3. \quad (3)$$

$$X = (\text{SFF triceps, mm} + \text{SFF back, mm} + \text{SFF supraspinatus, mm}) \cdot (\frac{170{,}18}{\text{BL, sm}})$$

Assessment of each component was done due to recommendations published by J.E.L. Carter, B.H. Heath [49]. The ECTO, MESO and ENDO values from 0.5 to 2.5 were considered as low contribution; from 2.6 to 5.5 as moderate, from 5.6 to 7 as high, 7.1 and above as very high contribution.

Body mass index was calculated using Kettle formula (4). Body weight deviations were assessed taking into account the 1995 World Health Organization (WHO) recommendation for the Asian cohort of subjects [50]: BMI <18.5 — underweight; BMI 18.6 to 22.9 — normal body weight; BMI 23.0 to 27.4 — overweight; >27.5 — obesity.

$$\text{BMI} = \frac{\text{BM, kg}}{\text{BL}^2\text{, m}}. \quad (4)$$

Comparison of anthropometric parameters and quantitative contribution of ecto-, meso- and endomorphic body type in residents of Dushanbe and GBAO was performed using the Mann–Whitney U-test. The decision to use a nonparametric test was made after checking the data using the Shapiro–Wilk test, which indicated a deviation from the normal distribution. Categorical variables, the numerical ratio of the distribution of the contribution of various components of somatotypes and body weight deviations were analyzed using the Pearson χ^2 test for 4×2 conjugation tables.

Calculations were performed using the statistical software Past version 2.17, Norway, Oslo (2012), the statistical algorithm StatXact-8 with the Cytel Studio software package version 8.0.0. Results were considered significant at $p < 0.05$. All continuous data are presented as arithmetic means and 95% confidence intervals (CI). Categorical data are presented as proportions with 95% CI.

RESULTS

As shown in Table 1, residents of Dushanbe, compared to their peers from GBAO, had statistically significantly higher values of body length and weight, width of large joints, sizes of all skin-fat pads and endomorphy in combination with lower values of meso- and ectomorphy. The values of shin and shoulder circumferences were not statistically significant (Table 1).

Data analysis showed that the distribution of contributions of ecto-, meso- and endomorphism of varying degrees (low, moderate, high, very high) is heterogeneous and statistically significantly differs in volunteers from Dushanbe and GBAO (Table 2, Fig. 2). Consequently, the degree of ecto-, meso- and endomorphism depends on the region of residence.

The distribution of weight deviations determined by BMI is heterogeneous and statistically significantly different in young men living in Dushanbe and GBAO (Table 3). Thus, the presence of underweight, normal or overweight, and obesity depends on the region of residence.

Table 1

Comparison of anthropometric parameters and ecto-, endo- and mesomorphic somatotype components contributions in young men living in different regions of the Republic of Tajikistan

Таблица 1

Сопоставление антропометрических параметров и вклада экто-, эндо- и мезоморфного компонента соматотипа у молодых мужчин, проживающих в различных регионах Республики Таджикистан

Параметр / Parameter	Душанбе / Dushanbe	ГБАО / GBAO	p-значения / p-value
Длина тела, см / Height, cm	171,18 (170,32; 172,04)	156,45 (155,31; 157,60)	$1{,}19\times10^{-61}$
Масса тела, кг / Body mass, kg	64,88 (63,75; 65,97)	44,23 (43,45; 45,02)	$1{,}87\times10^{-94}$
Индекс массы тела, кг/м^2 / Body mass index, kg/m^2	22,08 (21,76; 22,39)	18,04 (17,80; 18,28)	$1{,}47\times10^{-61}$
Ширина колена, см / Knee breadth, cm	6,38 (6,32; 6,45)	7,04 (6,91; 7,16)	$3{,}27\times10^{-15}$
Ширина локтя, см / Elbow breadth, cm	5,44 (5,40; 5,48)	5,74 (5,67; 5,82)	$1{,}10\times10^{-8}$
Окружность голени, см / Calf circumference, cm	36,88 (36,46; 37,30)	37,16 (36,67; 37,66)	0,409
Окружность плеча, см / Upper arm circumference, cm	32,40 (31,94; 32,87)	31,92 (31,40; 32,44)	0,1868
Кожно-жировая складка плечо, см / Upper arm skinfold, cm	3,09 (2,99; 3,18)	1,28 (1,23; 1,33)	$3{,}49\times10^{-99}$
Кожно-жировая складка под лопаткой, см / Subscapular skinfold, cm	2,55 (2,44; 2,69)	1,72 (1,66; 1,78)	$1{,}71\times10^{-19}$
Кожно-жировая складка голени, см / Calf skinfold, cm	0,67 (0,65; 0,68)	0,16 (0,16; 0,16)	$5{,}54\times10^{-114}$
Кожно-жировая складка надостная, см / Suprailiac skinfold, cm	1,87 (1,76; 1,98)	1,41 (1,35; 1,47)	$1{,}51\times10^{-6}$
Эктоморфия, усл. ед. / Ectomorphy, conv. units	2,76 (2,61; 2,91)	3,91 (3,74; 4,08)	$7{,}64\times10^{-19}$
Мезоморфия, усл. ед / Mesomorphy, conv. units	1,92 (1,75; 2,10)	4,88 (4,64; 5,11)	$1{,}86\times10^{-58}$
Эндоморфия, усл. ед / Endomorphy, conv. units	6,69 (6,51; 6,85)	4,42 (4,31; 4,54)	$3{,}06\times10^{-60}$

Table 2

Prevalence of various components of somatotypes contributions in young men living in Dushanbe and Gorno-Badakhshan Autonomous Oblast

Таблица 2

Распределение вкладов различных компонентов соматотипов у молодых мужчин, проживающих в г. Душанбе и Горно-Бадахшанской автономной области

Вклад / Contribution	Душанбе / Dushanbe	ГБАО / GBAO
Эктоморфия / Ectomorphy*		
Низкий / Low	0,42 (0,36; 0,48)	0,23 (0,17; 0,29)
Умеренный / Moderate	0,56 (0,50; 0,62)	0,62 (0,55; 0,69)
Высокий / High	0,02 (0,01; 0,04)	0,14 (0,10; 0,20)
Очень высокий / Very high	0 (0; 0,01)	0,01 (0,002; 0,03)
Мезоморфия / Mesomorphy**		
Низкий / Low	0,65 (0,59; 0,71)	0,13 (0,09; 0,18)
Умеренный / Moderate	0,32 (0,26; 0,38)	0,52 (0,44; 0,59)
Высокий / High	0,03 (0,01; 0,05)	0,23 (0,17; 0,29)
Очень высокий / Very high	0,01 (0,0004; 0,02)	0,13 (0,09; 0,18)
Эндоморфия / Endomorphy***		
Низкий / Low	0 (0; 0,01)	0,01 (0,002; 0,03)
Умеренный / Moderate	0,29 (0,23; 0,35)	0,83 (0,77; 0,88)
Высокий / High	0,31 (0,25; 0,37)	0,15 (0,10; 0,21)
Очень высокий / Very high	0,41 (0,34; 0,47)	0,01 (0,001; 0,03)

Note: / Примечание: *p=$3{,}69\times10^{-55}$; **p=$1{,}13\times10^{-53}$; ***p=$2{,}76\times10^{-14}$.

Table 3

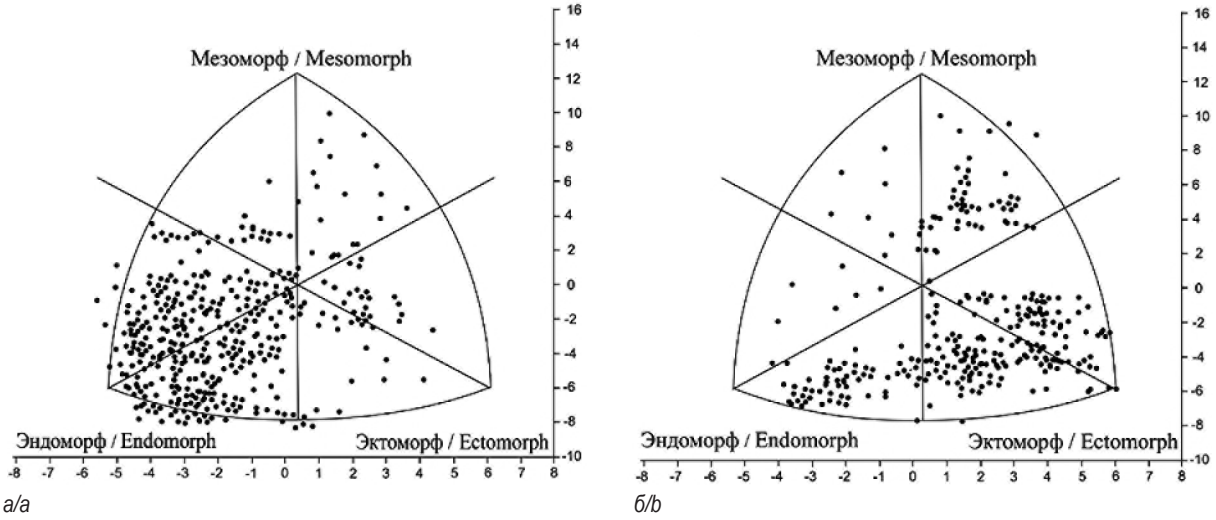
Distribution of body weight deviations in young men living in Dushanbe and Gorno-Badakhshan Autonomous Oblast

Таблица 3

Распределение отклонений массы тела у молодых мужчин, проживающих в г. Душанбе и Горно-Бадахшанской автономной области

Вклад / Contribution	Душанбе / Dushanbe	ГБАО / GBAO
Дефицит массы тела / Underweight	0,11 (0,07; 0,15)	0,61 (0,54; 0,68)
Нормальная масса тела / Normal body weight	0,55 (0,48; 0,61)	0,37 (0,30; 0,44)
Избыточная масса тела / Overweight	0,28 (0,22; 0,34)	0,02 (0,01; 0,05)
Ожирение / Obesity	0,07 (0,04; 0,10)	0,00 (0,00; 0,02)

Note: / ***Примечание:*** $p=1{,}607\times10^{-9}$.



а/a *б/b*

Fig. 2. Distribution of somatotype profiles in young men living in Dushanbe (*a*) and Gorno-Badakhshan Autonomous Oblast (*b*)

Рис. 2. Распределение профиля соматотипов у молодых мужчин, проживающих в г. Душанбе (*а*) и Горно-Бадахшанской автономной области (*б*)

DISCUSSION

To our knowledge, this is the first study to compare constitutional and anthropometric characteristics of young men living in Dushanbe and GBAO. The other studies with the similar aim were conducted in children, young women and did not take into account the territorial distribution of subjects [45, 47, 51]. Persons from Dushanbe surpassed their peers from GBAO in almost all anthropometric parameters: they are tall, heavy, with a large amount of subcutaneous fat and high bone mass (Table 1). Also, 72% of the capital's residents demonstrate a high and very high contribution of the endomorphic component of somatotype (Table 2, Fig. 2). In 35% of them, overweight and obesity were identified (Table 3). At the same time, subjects from GBAO were distinguished by a high and very high contribution of the mesomorphic (36%) component of somatotype in combination with underweight in 61% of subjects. For residents of Dushanbe, these indicators were recorded at the level of 4, 2 and 11%, respectively (Tables 2, 3, Fig. 2). The high and very high contribution of the ecto- and endomorphic somatotype among residents of GBAO was approximately equivalent — 15 and 16%, respectively.

In recent studies, examining more than 1000 subjects of different sexes and ages, it was found that the prevalence of overweight and obesity among residents of the capital of Tajikistan is 20–25% [52, 53]. This generally corresponds to the 35% prevalence of these disorders obtained in our work and the results of other studies involving adults [54] and children [55].

It is noted that the main reason for the increase in metabolic disorders is the formation of incorrect eating patterns and motor behavior in the population [51]. Recent surveys have shown an increase in the total volume of food consumed in combination with a decrease in physical activity in urban residents of Tajikistan [51, 53, 54]. More than 95% of respondents regularly consumed flour products, up to 30%

of respondents indicated a preference for fast food and its regular consumption 1–2 times a week [51, 53], while 63% of respondents did not eat enough vegetables and fruits [56]. Only 8% of 1000 participants said about regular physical activity in their life [51]. It is also assumed that leptin resistance [57] and insulin resistance [58, 59] play a significant role in the development of metabolic disorders in residents of Tajikistan. Despite the innate determination of body types [60], environmental factors and lifestyle can influence the expression of one or another component of the somatotype [40, 61]. For example, endomorphic body type shows a strong positive correlation with the thickness of skin and fat folds [62]. Thus, the endomorphization of body type in Dushanbe residents can be explained by the prevalence of excess body weight, which is also shown in this work. Dushanbe is the largest city, the capital of Tajikistan, with a widespread network of public catering establishments providing high-calorie food with fast service and a developed network of public transport, eliminating the need for walking long distances [63]. GBAO, on the contrary, is a rural region, the economy of households of which is based exclusively on the agricultural sector, which forces more than 70% of its residents to work daily on their own plots, consuming large amounts of energy [53]. Fast food establishments are not widespread in this region, and the socioeconomic conditions of the population are also low [63]. In this work we identified underweight in 60% of examined men living in GBAO. Thus, we assume that intensive physical activity in combination with a negative energy balance in the majority of GBAO residents may be the reason for the increase in ecto- and mesomorphic components of body type (Table 2, Fig. 2). It should be noted, that the obtained results partially contradict the literature, which reports that the prevalence of overweight among residents of GBAO is high. According to our data, only 2% of men from GBAO had overweight (Table 3), and at the same time 16% of them had endomorphic body type (Table 2). This can most likely be explained by the wide range of ages of the subjects and the limited scope of observations [56]. Our results partially coincide with the data published on the results of studies conducted in 2000–2008 involving newborn children from GBAO [64]. It should be emphasized that the age of participants in this study suggests that they were born in 2000–2002.

The article compared anthropometric parameters of residents of flat areas from the city of Dushanbe (706 m above sea level) and volunteers who have lived in high-altitude conditions since birth — the urban-type settlements of Vanch (1722 m above sea level), Roshtkala (2696 m above sea level), Ishkashim (3037 m above sea level), Shugnan (2287 m above sea level), Murghab (3618 m above sea level), the city of Khorog (2123 m), located in GBAO. Numerous studies have documented the impact of high altitude living conditions on the physical development of adults and children. Andrade et al. (2023) reported a dominant mesomorphic body type in prepubertal children living in high altitude areas of Argentina [65], which is consistent with the results of the survey of GBAO residents in this work. Observational studies conducted with the participation of Nepalese [66], Ethiopian [67], Tibetan [68], Sri Lankan [69], Peruvian [70, 71], Colombian [72, 78], Indian [36] cohorts revealed a deficit in linear growth in children living in high altitude conditions. In our study, residents of high-mountain regions also lagged behind their peers from Dushanbe in terms of apical body length (Table 1). Some authors believe that intrauterine hypoxia can cause growth retardation in fetuses and newborns from high-mountain regions [73]. Anthropometric deficiency and small lung size [74], as well as genetic polymorphism of cell cycle regulators and signalling molecules involved in the transduction of the key mechanism of bone lengthening [75], insulin-like growth factor 1 [76], are likely to be mechanisms limiting the rate of “catch-up” growth during the pubertal spurt [72, 77] in children with short stature due to the influence of high altitude. According to J.I. Martínez et al. (2021), maternal short stature caused by high altitude and hypoxia can be transmitted to the next generations [78]. It should also be noted that ectomorphic body type is positively associated with the polymorphism of the adrenoreceptor gene *ADRB3* rs4994 genotype Trp64Arg [79], the alpha-actinin-3 gene *ACTN3* RX [80], the brain-derived neurotrophic factor *BDNF* variant rs925946, neurexin-3-alpha NRXN3 variant rs10146997, the obesity-associated gene FTO variant rs9939609 and the protein kinase gene *MAP2K5* rs4776970 [17]. Mesomorphic type is associated with *NRXN3* variant rs10146997, *FTO* variant rs9939609 [17]. Endomorphic type is associated with *ADRB3* rs4994 genotype Trp64Trp [79], KLF14 polymorphism [81], *BDNF* variant rs925946, *NRXN3* variant rs10146997 [17]. Identification of genetic determination of body shape and its influence on motor functions and endurance in GBAO residents may become the subject of future research.

The high prevalence of underweight combined with meso- and ectomorphic components in residents of high-altitude regions of Tajikistan identified in the article also corresponds to literature data. Several independent studies have confirmed a reduced risk of overweight and obesity in residents of highland regions of Nepal [81], Tibet [82], and the United States [83].

The high prevalence of underweight in combination with meso- and ectomorphic components in high-altitude populations revealed in the article is a strong point of this work is the attempt to create a prognostic model of a personalized approach to monitoring the health status of residents of the

Republic of Tajikistan in connection with the territory of their residence and environmental features. Thus, the endomorphic somatotype revealed in men from Dushanbe, in case of their failure to comply with the principles of healthy nutrition and lifestyle, can be a predictor of metabolic disorders and associated functional disorders. In patients from Tajikistan suffering from obesity, a high levels of oxidative stress [84], insulin resistance [58, 59], and thyroid dysfunction [85] were revealed.

Ecto- and mesomorphic body types, found in residents of mountainous regions of the republic, can explain the development of underweight with improper nutrition and gastrointestinal tract disorders. Malnutrition and growth retardation are risk factors for the development of cognitive impairment [86, 87], decreased motor functions [88], micronutrient deficiency [89], and increased susceptibility to infectious diseases due to decreased immunity [90, 91]. However, the literature does not report the prevalence of diseases associated with growth retardation and low weight in residents of GBAO. Based on this, it can be assumed that young men have a compensated form of body weight deficiency. The prevalence of meso- and ectomophic body types has a “positive” side. As mentioned earlier, these somatotype variants are positively associated with the development of motor skills and endurance in athletes [9, 10, 92, 93]. Thus, healthy male athletes from GBAO may gain a biological advantage to achieve maximum efficiency of sports training and the likelihood of selection into professional teams [4, 11, 94].

The described patterns are the result of the implementation of a pilot project, so this study has a number of limitations. Firstly, the work did not involve determining the functional, hematological, genetic, biochemical characteristics of residents of Tajikistan and their correlation with the somatotype. Secondly, these results require reproducibility in other comparison groups (women, children). Thirdly, it is necessary to examine a sample from other areas, focusing on the influence of environmental factors, highlands, living in rural and urban regions of Tajikistan on the anthropometric characteristics of residents of the republic.

CONCLUSION

1. The anthropometric profile and constitutional diversity of young male residents of the Republic of Tajikistan depend on the region of their permanent residence.

2. The city of Dushanbe, the capital of the republic, is characterized by high urbanization, which has led to the creation of conditions that have affected the level of physical activity and nutrition of young people. Subjects from Dushanbe are distinguished by tall stature, high thickness of subcutaneous fat, massive bones, endomorphic body type, as well as the prevalence of overweight and obesity.

3. Their peers from GBAO, a region with an agrarian economy of households requiring energy-intensive manual work, were characterized by anthropometric deficits in linear growth, weight, bone mass, subcutaneous fat thickness in combination with a predominantly mesomorphic somatotype and a high prevalence of nutritional deficiencies.

The obtained results open up the possibility of introducing elements of a personalized approach to monitoring the health of residents of Tajikistan, expressed in the creation of prognostic models of nutritional status disorders and related pathologies. They can also be useful for the implementation of sports selection programs based on the analysis of physical development.

ADDITIONAL INFORMATION

Author contribution. Thereby, all authors made a substantial contribution to the conception of the study, acquisition, analysis, interpretation of data for the work, drafting and revising the article, final approval of the version to be published and agree to be accountable for all aspects of the study.

Competing interests. The authors declare that they have no competing interests.

Funding source. This study was not supported by any external sources of funding.

Consent for publication. Written consent was obtained from the patient for publication of relevant medical information within the manuscript.

ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ

Вклад авторов. Все авторы внесли существенный вклад в разработку концепции, проведение исследования и подготовку статьи, прочли и одобрили финальную версию перед публикацией.

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

Источник финансирования. Авторы заявляют об отсутствии внешнего финансирования при проведении исследования.

Информированное согласие на публикацию. Авторы получили письменное согласие пациентов на публикацию медицинских данных.

REFERENCES

1. Buśko K., Pastuszak A., Lipińska M., Lipińska M., Gryko K. Somatotype variables related to strength and power output in male basketball players. Acta Bioeng Biomech. 2017;19(2):161–167.

2. Ryan-Stewart H., Faulkner J., Jobson S. The influence of somatotype on anaerobic performance. PLoS One. 2018;13(5):e0197761.
3. Sterkowicz-Przybycień K., Sterkowicz S., Biskup L., Żarów R., Kryst Ł., Ozimek M. Somatotype, body composition, and physical fitness in artistic gymnasts depending on age and preferred event. PLoS One. 2019;14(2):e0211533.
4. Terzi E., Kalkavan A. To what extent do somatotype structures affect athletic performance in professional athletes? J Sports Med Phys Fitness. 2024;64(7):650–660.
5. Cinarli F.S., Buyukcelebi H., Esen O., Barasinska M., Cepicka L., Gabrys T., Nalbant U., Karayigit R. Does Dominant Somatotype Differentiate Performance of Jumping and Sprinting Variables in Young Healthy Adults? Int J Environ Res Public Health. 2022;19(19):11873.
6. González Macías M.E., Flores J. Somatotype, anthropometric characteristics, body composition, and global flexibility range in artistic gymnasts and sport hoop athletes. PLoS One. 2024;19(10):e0312555.
7. Cárdenas-Fernández V., Chinchilla-Minguet J.L., Castillo-Rodríguez A. Somatotype and Body Composition in Young Soccer Players According to the Playing Position and Sport Success. J Strength Cond Res. 2019;33(7):1904–1911.
8. Pezelj L., Milavić B., Milić M. Anthropometric and Somatotype Profile of Elite Finn Class Sailors. J Funct Morphol Kinesiol. 2024;9(3):121.
9. Ciftci R., Kurtoglu A. Examination of the Effect of Somatotype Profiles on Athletic Performance Indicators in Children Aged 48–72 Months. Cureus. 2023;15(9):e45430.
10. Kubo A., Murata S., Abiko T., Tanaka S. The relationship between children's somatotypes, motor examination results, and motor skills: assessing 6- to 10-year-olds. J Phys Ther Sci. 2022;34(7):492–496.
11. Peña-González I., Fernández-Fernández J., Moya-Ramón M., Cervelló E. Relative Age Effect, Biological Maturation, and Coaches' Efficacy Expectations in Young Male Soccer Players. Res Q Exerc Sport. 2018;89(3):373–379.
12. Erkudov V.O., Pugovkin A.P., Volkov A.Ya et al. Gender differences in the size of internal organs in 17-year-old adolescents with different somatotypes. Pediatr. 2017;5(8):67–73. (In Russian).
13. Erkudov V.O., Skripchenko N.V., Zaslavsky D.V. et al. Significance of constitutional factors in the development of body weight deficiency and excess in adolescents. Voprosy prakticheskoj pediatrii. 2019;14(4):21–29. (In Russian).
14. Erkudov V.O., Pugovkin A.P., Volkov A.Ya. et al. The role of human constitution in the formation of deficit and excess body weight in children of different ages. Pediatr. 2020;1(2):33–42. (In Russian).
15. Erkudov V.O., Pugovkin A.P., Volkov A.Ya. et al. Constitutional diversity of internal organ sizes in adolescents. Rossijskij vestnik perinatologii i pediatrii. 2019;2(64):94–99. (In Russian).
16. Galić B.S., Pavlica T., Udicki M., Stokić E., Mikalački M., Korovljev D., Čokorilo N., Drvendžija Z., Adamović D. Somatotype characteristics of normal-weight and obese women among different metabolic subtypes. Arch Endocrinol Metab. 2016;60(1):60–65.
17. Ibáñez-Zamacona M.E., Poveda A., Rebato E. Contribution of obesity associated genetic variants to anthropometric somatotype components. Anthropol Anz. 2019;76(2):101–111.
18. Liu X., Li W., Wen Y., Xu G., Zhou G., Qu Q., Hu Y., Saitierding Y., Mohetaer M., Buerlan Y., Zhong X., Xi H. Obesity and Heath-Carter Somatotyping of 3438 Adults in the Xinjiang Uygur Autonomous Region of China by Multivariate Analysis. Diabetes Metab Syndr Obes. 2021;14:659–670.
19. Yasuda T. Anthropometric, body composition, and somatotype characteristics of Japanese young women: Implications for normal-weight obesity syndrome and sarcopenia diagnosis criteria. Interv Med Appl Sci. 2019;11(2):117–121.
20. Browning D.J., Lee C. Somatotype, the risk of hydroxychloroquine retinopathy, and safe daily dosing guidelines. Clin Ophthalmol. 2018;12:811–818.
21. Çiftçi R. Evaluation of the effects of somatotype profiles on pain, proprioception, isokinetic muscle strength and kinesiophobia in patients with meniscopathy. J Back Musculoskelet Rehabil. 2023;36(6):1461–1468.
22. Divo M.J., Marin Oto M., Casanova Macario C., Cabrera Lopez C., de-Torres J.P., Marin Trigo J.M., Hersh C.P., Ezponda Casajús A., Maguire C., Pinto-Plata V.M., Polverino F., Ross J.C., DeMeo D., Bastarrika G., Silverman E.K., Celli B.R. Somatotypes trajectories during adulthood and their association with COPD phenotypes. ERJ Open Res. 2020;6(3):00122.
23. Ulubaba H.E., Cinarli F.S., Ciftci R., Ulutas O. Investigation of Kidney Morphology and Somatotype Components in Early-Stage Kidney Patients. Sisli Etfal Hastan Tip Bul. 2023;57(3):353–358.
24. Erkudov V.O., Pugovkin A.P., Volkov A.Ya. et al. Constitutional features of blood cellular composition in adolescents and young men. Morfologija. 2018;5(154):50–56. (In Russian).
25. Kazakova T.V., Nikolaev V.G. Regularities of constitutional variability of morphofunctional parameters of lymphocytes and neutrophilic granulocytes of blood. Morfologija. 2009;1(135):49–52. (In Russian).
26. Christakoudi S., Tsilidis K.K., Evangelou E., Riboli E. Associations of obesity and body shape with erythrocyte and reticulocyte parameters in the UK Biobank cohort. BMC Endocr Disord. 2023;23(1):161.
27. Kazakova T.V., Nikolaev V.G. Physical status and structure of vegetative tone of young men of different somatotypes. Sibirskoe medicinskoe obozrenie. 2006;41(4):74–77. (In Russian).
28. Subramanian S.K., Sharma V.K., Rajendran R. Assessment of heart rate variability for different somatotype category among adolescents. J Basic Clin Physiol Pharmacol. 2018;30(3).
29. Baranauskas M., Kupčiūnaitė I., Lieponienė J., Stukas R. Dominant Somatotype Development in Relation to Body Composition and Dietary Macronutrient Intake among High-Performance Athletes in Water, Cycling and Combat Sports. Nutrients. 2024;16(10):1493.
30. Irandoust K., Taheri M., Mirmoezzi M., H'mida C., Chtourou H., Trabelsi K., Ammar A., Nikolaidis P.T., Rosemann T., Knechtle B. The Effect of Aquatic Exercise on Postural Mobility of Healthy Older Adults with Endomorphic Somatotype. Int J Environ Res Public Health. 2019;16(22):4387.

31. Voroncov I.M., Fateeva E.M. Natural feeding of children. Its significance and support. Saint Petersburg: Foliant; 1998. (In Russian). EDN: VAJKDL.
32. Kolesnikov V.A., Rudnev S.G., Nikolaev D.V. et al. On a new protocol for assessing somatotype by Heath-Carter scheme in the software of bioimpedance body composition analyzer. Vestnik Moskovskogo universiteta. Serija 23: Antropologija. 2016;4:4–13. (In Russian).
33. Sanchat N.O., Kurganskaya T.M., Gricinskaya V.L. Assessment and self-assessment of physical development among senior schoolchildren in the Republic of Tuva. Children's Medicine of the North-West. 2024;12(4):182–191. (In Russian). DOI: 10.56871/CmN-W.2024.25.29.015.
34. Krzykała M., Karpowicz M., Strzelczyk R., Pluta B., Podciechowska K., Karpowicz K. Morphological asymmetry, sex and dominant somatotype among Polish youth. PLoS One. 2020;15(9):e0238706.
35. Pereira S., Katzmarzyk P.T., Gomes T.N., Souza M., Chaves R.N., Santos F.K.D., Santos D., Hedeker D., Maia J.A.R. Multilevel modelling of somatotype components: the Portuguese sibling study on growth, fitness, lifestyle and health. Ann Hum Biol. 2017;44(4):316–324.
36. Yang W.C., Fu C.M., Su B.W., Ouyang C.M., Yang K.C. Child Growth Curves in High-Altitude Ladakh: Results from a Cohort Study. Int J Environ Res Public Health. 2020;17(10):3652.
37. Her E.S., Park J.K., Oh Y.K. Influence of body shape on health-related quality of life in Korean adults: The mediating effect of self-rated health. PLoS One. 2023;18(10):e0293286.
38. Lizana P.A., González S., Lera L., Leyton B. Association between body composition, somatotype and socioeconomic status in chilean children and adolescents at different school levels. J Biosoc Sci. 2018;50(1):53–69.
39. Rozumbetov K.U., Ibraimova A.K. Determination of BMI and physique of girls living in ecologically unfavorable conditions of the Aral Sea region. Bjulleten' nauki i praktiki. 2021;7(6):191–199. (In Russian).
40. Erkudov V.O., Rozumbetov K.U., González-Fernández F.T., Pugovkin A.P., Nazhimov I.I., Matchanov A.T., Ceylan H.İ. The Effect of Environmental Disasters on Endocrine Status, Hematology Parameters, Body Composition, and Physical Performance in Young Soccer Players: A Case Study of the Aral Sea Region. Life. 2023;13(7):1503.
41. Rozumbetov K.U., Matchanov A.T., Esemuratova S.P., Nisanova S.N. Characteristics of the distribution of somatotypes and assessment of physical development in girls living in the Republic of Karakalpakstan. Theoretical & Applied Science. 2021;6:130–134.
42. Abdrakhmanova Sh.Z., Slazhneva T.I., Adaeva A.A., Imasheva B.S., Aringazina A.M., Akimbayeva A.A., Suleimanova N.A. Anthropometric indicators of underweight and overweight of children of primary school age in the Republic of Kazakhstan. Nauka i Zdravoohranenie. 2021;6(23):76–87. (In Russian).
43. Kononets I.E., Adaeva A.M., Uralieva Ch.K. Features of vegetative homeostasis and physical development of adolescents living in the low mountains of Kyrgyzstan. Jelektronnyj nauchnyj zhurnal "Biologija i integrativnaja medicina". 2021;6(53):155–161. (In Russian).
44. Sattarov A.E., Karelina N.R. Features of growth processes in boys and boys of different proportions and physique living in the southern part of Kyrgyzstan. Pediatr. 2018;9(5):47–52. (In Russian). DOI: 10.17816/PED9547-52.
45. Komilova B.I., Fozilov N.S. Comparative assessment of physical development of young men and girls in Tajikistan. Children's Medicine of the North-West. 2023;11(2):73–79. (In Russian).
46. Nikolaeva V.V., Shukurov F.A., Ashurov A.T. Ethnic peculiarities of growth and weight of girls of the Hissar Valley of Tajikistan. Jelektronnyj nauchnyj zhurnal "Biologii i integrativnaja medicina". 2020;6(46):23–30. (In Russian).
47. Khalimova F.T., Nazarov J.T., Irgasheva J. Individual-typological characterization of students by their somatotype. Jelektronnyj nauchnyj zhurnal "Biologija i integrativnaja medicina". 2023;2(61):5–16. (In Russian).
48. Negasheva M.A. Fundamentals of anthropometry: textbook for students in educational organizations of higher education in the direction 03.06.01 "Biology". Moscow: Econ-Inform; 2017. (In Russian).
49. Carter J.E.L. Heath B.H. Somatotyping. Development and Applications; Cambridge University Press: Cambridge, UK; 1990.
50. Dedov I.I., Shestakova M.V., Melnichenko G.A. et al. Interdisciplinary clinical recommendations "Treatment of obesity and comorbid diseases". Ozhirenie i metabolizm. 2021;18(1):5–99. (In Russian).
51. Sazonova O.V., Daburov K.N., Gorbachev D.O., Borodina L.M., Gavryushin M.Y., Sharifov R.N., Rakhmonaliev O.B. Study of adherence to the principles of rational nutrition by different professional groups living in the Russian Federation and the Republic of Tajikistan. Nauka i innovacii v medicine. 2020;5(3):154–158. (In Russian).
52. Abdullozoda S.M. Prevalence of obesity among the adult population of Tajikistan. Vestnik Avicenny. 2022;24(1):1928. (In Russian).
53. Abdullozoda S.M., Usmanova G.M. Screening of obesity among the adult population of Tajikistan (on the example of pilot districts). Vestnik Avicenny. 2023;25(3):356–369. (In Russian).
54. Pirmatova M.A., Pirmatova T. Risk factors of overweight and obesity among young people of Tajikistan. Mezhdunarodnyj nauchno-issledovatel'skij zhurnal. 2021;4-2(106):185–187. (In Russian).
55. Abdullaeva N.Sh., Olimova K.S. Features of physical development of children of early age in Dushanbe. Vestnik Akademii medicinskih nauk Tadzhikistana. 2018;8(2). (In Russian).
56. Gulov M.K., Abdulloev S.M., Gulbekova Z.A., Makhmudov H.R. Screening of risk factors for chronic non-infectious diseases among the population of high mountainous areas of Tajikistan. Vestnik Avicenny. 2020;22(2):209–221. (In Russian).
57. Abdullozoda S.M., Usmanova G.M., Kobilov K.K., Umarova Z.A. Leptin content in the adult population of the Republic of Tajikistan

with different body mass index. Medicinskij vestnik Nacional'noj akademii nauk Tadzhikistana. 2023d;3:5–12. (In Russian).
58. Abdullozoda S.M. Epidemiology of diabetes mellitus among the adult population of Tajikistan. Zdravoohranenie Tadzhikistana. 2021;4:11–23. (In Russian).
59. Matthys B., Steinmann P., Karimova G., Tagoev T., Abdurahmonov A., Costa J., Kasimova S.J., Wyss K. Prevalence of impaired glucose metabolism and potential predictors: a rapid appraisal among ≥45 years old residents of southern Tajikistan. J Diabetes. 2015;7(4):540–547.
60. Valente-dos-Santos J., Coelho-e-Silva M.J., Simões F., Figueiredo A.J., Leite N., Elferink-Gemser M.T., Malina R.M., Sherar L. Modeling developmental changes in functional capacities and soccer-specific skills in male players aged 11–17 years. Pediatr Exerc Sci. 2012;24(4):603–621.
61. Slimani M., Nikolaidis P.T. Anthropometric and physiological characteristics of male soccer players according to their competitive level, playing position and age group: a systematic review. J Sports Med Phys Fitness. 2019;59(1):141–163.
62. Pastuszak A., Gajewski J., Buśko K. The impact of skinfolds measurement on somatotype determination in Heath-Carter method. PLoS One. 2019;14(9):e0222100.
63. Sousa S., Morais I.L., Albuquerque G., Gelormini M., Casal S., Pinho O., Motta C., Damasceno A., Moreira P., Breda J., Lunet N., Padrão P. A Cross-Sectional Study of the Street Foods Purchased by Customers in Urban Areas of Central Asia. Nutrients. 2021;13(10):3651.
64. Kayumov A.K. Vatanbekova G.S. Influence of high and middle mountains on anthropometric indices of boys aged up to three years. Vestnik Avicenny. 2009;4(41):103–106. (In Russian).
65. Andrade L.D., Vilca N.G., Figueroa M.I., Martínez J.I., Alfaro Gómez E.L., Dipierri J.E. Somatotype altitudinal variation and its relationship with the nutritional status of children in the Jujuy province, Argentina. Am J Hum Biol. 2023;35(9):e23910.
66. Quinn E.A., Sangmo J., Burack S., Childs G. Childhood growth and education migration among ethnic Tibetan children from Nepal. Am J Biol Anthropol. 2023;180(3):427–441.
67. Baye K., Hirvonen K. Evaluation of Linear Growth at Higher Altitudes. JAMA Pediatr. 2020;174(10):977–984.
68. Dang S., Yan H., Yamamoto S. High altitude and early childhood growth retardation: new evidence from Tibet. Eur J Clin Nutr. 2008;62(3):342–348.
69. Rannan-Eliya R.P., Hossain S.M., Anuranga C., Wickramasinghe R., Jayatissa R., Abeykoon A.T. Trends and determinants of childhood stunting and underweight in Sri Lanka. Ceylon Med J. 2013;58(1):10–18.
70. Bustamante A., Santos C., Pereira S., Freitas D., Katzmarzyk P.T., Maia J. Regional variation in growth status. The Peruvian health and optimist growth study. Am J Hum Biol. 2022;34(5):e23704.
71. Sanchez-Macedo L., Vidal-Espinoza R., Minango-Negrete J., Ronque E.V., Campos L.F.C.C., Fuentes-López J., Vargas-Ramos E., Rivera-Portugal M., Cossio-Bolaños M., Gomez-Campos R. Parameters of pubertal growth spurt in children and adolescents living at high altitude in Peru. J Pediatr (Rio J). 2024;100(2):189–195.
72. Cossio-Bolaños M.A., Vidal-Espinoza R., Minango-Negrete J., Olivares P.R., Urzua-Alul L., de Campos L.F.C.C., Fuentes-López J., Sanchez-Macedo L., Diaz-Bonilla E., Torres-Galvis C., Gomez-Campos R. Estimation of Pubertal Growth Spurt Parameters in Children and Adolescents Living at Moderate Altitude in Colombia. Front Endocrinol (Lausanne). 2021;12:718292.
73. Dolma P., Angchuk P.T., Jain V., Dadhwal V., Kular D., Williams D.J., Montgomery H.E., Hillman S.L. High-altitude population neonatal and maternal phenotypes associated with birthweight protection. Pediatr Res. 2022;91(1):137–142.
74. Weitz C.A., Garruto R.M. Stunting and the Prediction of Lung Volumes Among Tibetan Children and Adolescents at High Altitude. High Alt Med Biol. 2015;16(4):306–317.
75. Racine H.L., Serrat M.A. The Actions of IGF-1 in the Growth Plate and Its Role in Postnatal Bone Elongation. Curr Osteoporos Rep. 2020;18(3):210–227.
76. Sharma V., Varshney R., Sethy N.K. Human adaptation to high altitude: a review of convergence between genomic and proteomic signatures. Hum Genomics. 2022;16(1):21.
77. Santos C., Bustamante A., Katzmarzyk P.T., Vasconcelos O., Garganta R., Freitas D., Mirzaei-Salehabadi S., Maia J. Growth velocity curves and pubertal spurt parameters of Peruvian children and adolescents living at different altitudes. The Peruvian health and optimist growth study. Am J Hum Biol. 2019;31(6):e23301.
78. Martínez J.I., Figueroa M.I., Alfaro Gómez E.L., Dipierri J.E. Newborn anthropometry, maternal capital, and altitude in the highland population from the province of Jujuy, Argentina. Am J Phys Anthropol. 2021;175(1):25–35.
79. Potocka N., Skrzypa M., Zadarko-Domaradzka M., Barabasz Z., Penar-Zadarko B., Sakowicz A., Zadarko E., Zawlik I. Effects of the Trp64Arg Polymorphism in the ADRB3 Gene on Body Composition, Cardiorespiratory Fitness, and Physical Activity in Healthy Adults. Genes (Basel). 2023;14(8):1541.
80. Potocka N., Penar-Zadarko B., Skrzypa M., Braun M., Zadarko-Domaradzka M., Ozimek M., Nizioł-Babiarz E., Barabasz Z., Zawlik I., Zadarko E. Association of ACTN3 Polymorphism with Body Somatotype and Cardiorespiratory Fitness in Young Healthy Adults. Int J Environ Res Public Health. 2019;16(9):1489.
81. Mehata S., Shrestha N., Ghimire S., Atkins E., Karki D.K., Mishra S.R. Association of altitude and urbanization with hypertension and obesity: analysis of the Nepal Demographic and Health Survey 2016. Int Health. 2021;13(2):151–160.
82. Li X., Li Y., Xing X., Liu Y., Zhou Z., Liu S., Tian Y., Nima Q., Yin L., Yu B. Urban-rural disparities in the association between long-term exposure to high altitude and malnutrition among children under 5 years old: evidence from a cross-sectional study in Tibet. Public Health Nutr. 2023;26(4):844–853.

83. Maxfield A., Hadley C., Hruschka D.J. The relationship between altitude and BMI varies across low- and middle-income countries. Am J Hum Biol. 2024;36(5):e24036.
84. Abdullozoda S.M., Usmanova G.M., Gulbekova Z.A. Markers of oxidative stress and antioxidant defense in obesity. Vestnik poslediplomnogo obrazovanija v sfere zdravoohranenija. 2023b;3:5–13. (In Russian).
85. Abdullozoda S.M., Usmanova G.M., Kobilov K.K., Umarova Z.A. Features of thyroid hormone metabolism in obesity. Vestnik poslediplomnogo obrazovanija v sfere zdravoohranenija. 2023c;2:5–12. (In Russian).
86. Deshpande A., Ramachandran R. Early childhood stunting and later life outcomes: A longitudinal analysis. Econ Hum Biol. 2022;44:101099.
87. Robinson J.A., Dinh P.T.T. High doses of a national preschool program are associated with the long-term mitigation of adverse outcomes in cognitive development and life satisfaction among children who experience early stunting: a multi-site longitudinal study in Vietnam. Front Public Health. 2023;11:1087349.
88. Kulkarni S., Ramakrishnan U., Dearden K.A., Marsh D.R., Ha T.T., Tran T.D., Pachón H. Greater length-for-age increases the odds of attaining motor milestones in Vietnamese children aged 5-18 months. Asia Pac J Clin Nutr. 2012;21(2):241–246.
89. Tan S.Y., Poh B.K., Sekartini R., Rojroongwasinkul N., Tran T.N., Wong J.E., Novita Chandra D., Pongcharoen T., Tran K.V., Actis-Goretta L., Vonk M.M., Ng S.A., Parikh P., Khouw I., SEANUTS II Study Group. South East Asian Nutrition Surveys (SEANUTS) II — a multi-country evaluation of nutrition and lifestyle indicators in children aged 12 years and below: rationale and design. Public Health Nutr. 2024;27(1):e150.
90. Caulfield L.E., de Onis M., Blössner M., Black R.E. Undernutrition as an underlying cause of child deaths associated with diarrhea, pneumonia, malaria, and measles. Am J Clin Nutr. 2004;80(1):193–198.
91. Müller O., Krawinkel M. Malnutrition and health in developing countries. CMAJ. 2005;173(3):279–286.
92. Yang L.T., Wang N., Li Z.X., Liu C., He X., Zhang J.F., Han H., Wen Y.F., Qian Y.H., Xi H.J. Study on the adult physique with the Heath-Carter anthropometric somatotype in the Han of Xi'an, China. Anat Sci Int. 2016;91(2):180–187.
93. Sánchez-Macedo L., Vidal-Espinoza R., Gómez-Campos R., Díaz-Bonilla E., Torres-Galvis C.L., Urzua-Alul L., Castelli-Correia de Campos L.F., Sulla Torres J., Lee-Andruske C., Cossio Bolaños M. Physical growth of children and adolescents living at a moderate altitude: proposed percentiles based on age and sex. Nutr Hosp. 2021;38(6):1238–1247.
94. Wu S., Hsu L.A., Teng M.S., Chou H.H., Ko Y.L. Differential Genetic and Epigenetic Effects of the KLF14 Gene on Body Shape Indices and Metabolic Traits. Int J Mol Sci. 2022;23(8):4165.

ЛИТЕРАТУРА

1. Buśko K., Pastuszak A., Lipińska M., Lipińska M., Gryko K. Somatotype variables related to strength and power output in male basketball players. Acta Bioeng Biomech. 2017;19(2):161–167.
2. Ryan-Stewart H., Faulkner J., Jobson S. The influence of somatotype on anaerobic performance. PLoS One. 2018;13(5):e0197761.
3. Sterkowicz-Przybycień K., Sterkowicz S., Biskup L., Żarów R., Kryst Ł., Ozimek M. Somatotype, body composition, and physical fitness in artistic gymnasts depending on age and preferred event. PLoS One. 2019;14(2):e0211533.
4. Terzi E., Kalkavan A. To what extent do somatotype structures affect athletic performance in professional athletes? J Sports Med Phys Fitness. 2024;64(7):650–660.
5. Cinarli F.S., Buyukcelebi H., Esen O., Barasinska M., Cepicka L., Gabrys T., Nalbant U., Karayigit R. Does Dominant Somatotype Differentiate Performance of Jumping and Sprinting Variables in Young Healthy Adults? Int J Environ Res Public Health. 2022;19(19):11873.
6. González Macías M.E., Flores J. Somatotype, anthropometric characteristics, body composition, and global flexibility range in artistic gymnasts and sport hoop athletes. PLoS One. 2024;19(10):e0312555.
7. Cárdenas-Fernández V., Chinchilla-Minguet J.L., Castillo-Rodríguez A. Somatotype and Body Composition in Young Soccer Players According to the Playing Position and Sport Success. J Strength Cond Res. 2019;33(7):1904–1911.
8. Pezelj L., Milavić B., Milić M. Anthropometric and Somatotype Profile of Elite Finn Class Sailors. J Funct Morphol Kinesiol. 2024;9(3):121.
9. Ciftci R., Kurtoglu A. Examination of the Effect of Somatotype Profiles on Athletic Performance Indicators in Children Aged 48-72 Months. Cureus. 2023;15(9):e45430.
10. Kubo A., Murata S., Abiko T., Tanaka S. The relationship between children's somatotypes, motor examination results, and motor skills: assessing 6- to 10-year-olds. J Phys Ther Sci. 2022;34(7):492–496.
11. Peña-González I., Fernández-Fernández J., Moya-Ramón M., Cervelló E. Relative Age Effect, Biological Maturation, and Coaches' Efficacy Expectations in Young Male Soccer Players. Res Q Exerc Sport. 2018;89(3):373–379.
12. Еркудов В.О., Пуговкин А.П., Волков А.Я. и др. Гендерные различия размеров внутренних органов у 17-летних подростков с различными соматотипами. Педиатр. 2017;5(8):67–73.
13. Еркудов В.О., Скрипченко Н.В., Заславский Д.В. и др. Значение конституциональных факторов в развитии дефицита и избытка массы тела у подростков. Вопросы практической педиатрии. 2019;14(4):21–29.
14. Еркудов В.О., Пуговкин А.П., Волков А.Я. и др. Роль конституции человека в формировании дефицита и избытка массы тела у детей различного возраста. Педиатр. 2020;1(2):33–42.
15. Еркудов В.О., Пуговкин А.П., Волков А.Я. и др. Конституциональное разнообразие размеров внутренних органов у подростков. Российский вестник перинатологии и педиатрии. 2019;2(64):94–99.
16. Galić B.S., Pavlica T., Udicki M., Stokić E., Mikalački M., Korovljev D., Čokorilo N., Drvendžija Z., Adamović D. Somatotype characteristics of normal-weight and obese women among different metabolic subtypes. Arch Endocrinol Metab. 2016;60(1):60–65.

17. Ibáñez-Zamacona M.E., Poveda A., Rebato E. Contribution of obesity associated genetic variants to anthropometric somatotype components. Anthropol Anz. 2019;76(2):101–111.
18. Liu X., Li W., Wen Y., Xu G., Zhou G., Qu Q., Hu Y., Saitierding Y., Mohetaer M., Buerlan Y., Zhong X., Xi H. Obesity and Heath-Carter Somatotyping of 3438 Adults in the Xinjiang Uygur Autonomous Region of China by Multivariate Analysis. Diabetes Metab Syndr Obes. 2021;14:659–670.
19. Yasuda T. Anthropometric, body composition, and somatotype characteristics of Japanese young women: Implications for normal-weight obesity syndrome and sarcopenia diagnosis criteria. Interv Med Appl Sci. 2019;11(2):117–121.
20. Browning D.J., Lee C. Somatotype, the risk of hydroxychloroquine retinopathy, and safe daily dosing guidelines. Clin Ophthalmol. 2018;12:811–818.
21. Çiftçi R. Evaluation of the effects of somatotype profiles on pain, proprioception, isokinetic muscle strength and kinesiophobia in patients with meniscopathy. J Back Musculoskelet Rehabil. 2023;36(6):1461–1468.
22. Divo M.J., Marin Oto M., Casanova Macario C., Cabrera Lopez C., de-Torres J.P., Marin Trigo J.M., Hersh C.P., Ezponda Casajús A., Maguire C., Pinto-Plata V.M., Polverino F., Ross J.C., DeMeo D., Bastarrika G., Silverman E.K., Celli B.R. Somatotypes trajectories during adulthood and their association with COPD phenotypes. ERJ Open Res. 2020;6(3):00122.
23. Ulubaba H.E., Cinarli F.S., Ciftci R., Ulutas O. Investigation of Kidney Morphology and Somatotype Components in Early-Stage Kidney Patients. Sisli Etfal Hastan Tip Bul. 2023;57(3):353–358.
24. Еркудов В.О., Пуговкин А.П., Волков А.Я. и др. Конституциональные особенности клеточного состава крови у подростков и юношей. Морфология. 2018;5(154):50–56.
25. Казакова Т.В., Николаев В.Г. Закономерности конституциональной изменчивости морфофункциональных показателей лимфоцитов и нейтрофильных гранулоцитов крови. Морфология. 2009;1(135):49–52.
26. Christakoudi S., Tsilidis K.K., Evangelou E., Riboli E. Associations of obesity and body shape with erythrocyte and reticulocyte parameters in the UK Biobank cohort. BMC Endocr Disord. 2023;23(1):161.
27. Казакова Т.В., Николаев В.Г. Физический статус и структура вегетативного тонуса юношей разных соматотипов. Сибирское медицинское обозрение. 2006;41(4):74–77.
28. Subramanian S.K., Sharma V.K., Rajendran R. Assessment of heart rate variability for different somatotype category among adolescents. J Basic Clin Physiol Pharmacol. 2018;30(3).
29. Baranauskas M., Kupčiūnaitė I., Lieponienė J., Stukas R. Dominant Somatotype Development in Relation to Body Composition and Dietary Macronutrient Intake among High-Performance Athletes in Water, Cycling and Combat Sports. Nutrients. 2024;16(10):1493.
30. Irandoust K., Taheri M., Mirmoezzi M., H'mida C., Chtourou H., Trabelsi K., Ammar A., Nikolaidis P.T., Rosemann T., Knechtle B. The Effect of Aquatic Exercise on Postural Mobility of Healthy Older Adults with Endomorphic Somatotype. Int J Environ Res Public Health. 2019;16(22):4387.
31. Воронцов И.М., Фатеева Е.М. Естественное вскармливание детей. Его значение и поддержка. СПб.: Фолиант; 1998. EDN: VAJKDL
32. Колесников В.А., Руднев С.Г., Николаев Д.В. и др. О новом протоколе оценки соматотипа по схеме Хит–Картера в программном обеспечении биоимпедансного анализатора состава тела. Вестник Московского университета. Серия 23: Антропология. 2016;4:4–13.
33. Санчат Н.О., Курганская Т.М., Грицинская В.Л. Оценка и самооценка физического развития у старших школьников в Республике Тыва. Children's Medicine of the North-West. 2024;12(4):182–191. DOI: 10.56871/CmN-W.2024.25.29.015.
34. Krzykała M., Karpowicz M., Strzelczyk R., Pluta B., Podciechowska K., Karpowicz K. Morphological asymmetry, sex and dominant somatotype among Polish youth. PLoS One. 2020;15(9):e0238706.
35. Pereira S., Katzmarzyk P.T., Gomes T.N., Souza M., Chaves R.N., Santos F.K.D., Santos D., Hedeker D., Maia J.A.R. Multilevel modelling of somatotype components: the Portuguese sibling study on growth, fitness, lifestyle and health. Ann Hum Biol. 2017;44(4):316–324.
36. Yang W.C., Fu C.M., Su B.W., Ouyang C.M., Yang K.C. Child Growth Curves in High-Altitude Ladakh: Results from a Cohort Study. Int J Environ Res Public Health. 2020;17(10):3652.
37. Her E.S., Park J.K., Oh Y.K. Influence of body shape on health-related quality of life in Korean adults: The mediating effect of self-rated health. PLoS One. 2023;18(10):e0293286.
38. Lizana P.A., González S., Lera L., Leyton B. Association between body composition, somatotype and socioeconomic status in chilean children and adolescents at different school levels. J Biosoc Sci. 2018;50(1):53–69.
39. Розумбетов К.У., Ибраймова А.К. Определение ИМТ и телосложения девушек, проживающих в экологически неблагополучных условиях Приаралья. Бюллетень науки и практики. 2021;7(6):191–199.
40. Erkudov V.O., Rozumbetov K.U., González-Fernández F.T., Pugovkin A.P., Nazhimov I.I., Matchanov A.T., Ceylan H.İ. The Effect of Environmental Disasters on Endocrine Status, Hematology Parameters, Body Composition, and Physical Performance in Young Soccer Players: A Case Study of the Aral Sea Region. Life. 2023;13(7):1503.
41. Rozumbetov K.U., Matchanov A.T., Esemuratova S.P., Nisanova S.N. Characteristics of the distribution of somatotypes and assessment of physical development in girls living in the Republic of Karakalpakstan. Theoretical & Applied Science. 2021;6:130–134.
42. Абдрахманова Ш.З., Слажнева Т.И., Адаева А.А., Имашева Б.С., Арингазина А.М., Акимбаева А.А., Сулейманова Н.А. Антропометрические показатели недостаточной и избыточной массы тела детей младшего школьного возраста в Республике Казахстан. Наука и Здравоохранение. 2021;6(23):76–87.

43. Кононец И.Е., Адаева А.М., Уралиева Ч.К. Особенности вегетативного гомеостаза и физического развития подростков, проживающих в условиях низкогорья Кыргызстана. Электронный научный журнал «Биология и интегративная медицина». 2021;6(53):155–161.
44. Саттаров А.Э., Карелина Н.Р. Особенности ростовых процессов у мальчиков и юношей различных пропорций и телосложения, проживающих в южной части Кыргызстана. Педиатр. 2018;9(5):47–52. DOI: 10.17816/PED9547-52.
45. Комилова Б.И., Фозилов Н.С. Сравнительная оценка физического развития юношей и девушек Таджикистана. Children's Medicine of the North- West. 2023;11(2):73–79.
46. Николаева В.В., Шукуров Ф.А., Ашуров А.Т. Этнические особенности роста и веса девушек Гиссарской Долины Таджикистана. Электронный научный журнал «Биологии и интегративная медицина». 2020;6(46):23–30.
47. Халимова Ф.Т., Назаров Дж.Т., Иргашева Дж. Индивидуально-типологическая характеристика студентов по их соматотипу. Электронный научный журнал «Биология и интегративная медицина. 2023;2(61):5–16.
48. Негашева М.А. Основы антропометрии: учебное пособие для обучающихся в образовательных организациях высшего образования по направлению 03.06.01 «Биология». М.: Экон-Информ; 2017.
49. Carter J.E.L., Heath B.H. Somatotyping. Development and Applications; Cambridge University Press: Cambridge, UK; 1990.
50. Дедов И.И., Шестакова М.В., Мельниченко Г.А. и др. Междисциплинарные клинические рекомендации «Лечение ожирения и коморбидных заболеваний». Ожирение и метаболизм. 2021;18(1):5–99.
51. Сазонова О.В., Дабуров К.Н., Горбачев Д.О., Бородина Л.М., Гаврюшин М.Ю., Шарифов Р.Н., Рахмоналиев О.Б. Изучение соблюдения принципов рационального питания различными профессиональными группами, проживающими в Российской Федерации и Республике Таджикистан. Наука и инновации в медицине. 2020;5(3):154–158.
52. Абдуллозода С.М. Распространенность ожирения среди взрослого населения Таджикистана. Вестник Авиценны. 2022;24(1):1928.
53. Абдуллозода С.М., Усманова Г.М. Скрининг ожирения среди взрослого населения Таджикистана (на примере пилотных районов). Вестник Авиценны. 2023;25(3):356–369.
54. Пирматова М.А., Пирматова Т. Факторы риска избыточного веса и ожирения среди молодёжи Таджикистана. Международный научно-исследовательский журнал. 2021;4-2(106):185–187.
55. Абдуллаева Н.Ш., Олимова К.С. Особенности физического развития детей раннего возраста г. Душанбе. Вестник Академии медицинских наук Таджикистана. 2018;8(2).
56. Гулов М.К., Абдуллоев С.М., Гулбекова З.А., Махмудов Х.Р. Скрининг факторов риска хронических неинфекционных заболеваний среди населения высокогорной местности Таджикистана. Вестник Авиценны. 2020;22(2):209–221.
57. Абдуллозода С.М., Усманова Г.М., Кобилов К.К., Умарова З.А. Содержание лептина у взрослого населения Республики Таджикистан с различным индексом массы тела. Медицинский вестник Национальной академии наук Таджикистана. 2023d;3:5–12.
58. Абдуллозода С.М. Эпидемиология сахарного диабета среди взрослого населения Таджикистана. Здравоохранение Таджикистана. 2021;4:11–23.
59. Matthys B., Steinmann P., Karimova G., Tagoev T., Abdurahmonov A., Costa J., Kasimova S.J., Wyss K. Prevalence of impaired glucose metabolism and potential predictors: a rapid appraisal among ≥45 years old residents of southern Tajikistan. J Diabetes. 2015;7(4):540–547.
60. Valente-dos-Santos J., Coelho-e-Silva M.J., Simões F., Figueiredo A.J., Leite N., Elferink-Gemser M.T., Malina R.M., Sherar L. Modeling developmental changes in functional capacities and soccer-specific skills in male players aged 11–17 years. Pediatr Exerc Sci. 2012;24(4):603–621.
61. Slimani M., Nikolaidis P.T. Anthropometric and physiological characteristics of male soccer players according to their competitive level, playing position and age group: a systematic review. J Sports Med Phys Fitness. 2019;59(1):141–163.
62. Pastuszak A., Gajewski J., Buśko K. The impact of skinfolds measurement on somatotype determination in Heath-Carter method. PLoS One. 2019;14(9):e0222100.
63. Sousa S., Morais I.L., Albuquerque G., Gelormini M., Casal S., Pinho O., Motta C., Damasceno A., Moreira P., Breda J., Lunet N., Padrão P. A Cross-Sectional Study of the Street Foods Purchased by Customers in Urban Areas of Central Asia. Nutrients. 2021;13(10):3651.
64. Каюмов А.К. Ватанбекова Г.С. Влияние высокогорья и среднегорья на антропометрические показатели мальчиков в возрасте до трех лет. Вестник Авиценны. 2009;4(41):103–106.
65. Andrade L.D., Vilca N.G., Figueroa M.I., Martínez J.I., Alfaro Gómez E.L., Dipierri J.E. Somatotype altitudinal variation and its relationship with the nutritional status of children in the Jujuy province, Argentina. Am J Hum Biol. 2023;35(9):e23910.
66. Quinn E.A., Sangmo J., Burack S., Childs G. Childhood growth and education migration among ethnic Tibetan children from Nepal. Am J Biol Anthropol. 2023;180(3):427–441.
67. Baye K., Hirvonen K. Evaluation of Linear Growth at Higher Altitudes. JAMA Pediatr. 2020;174(10):977–984.
68. Dang S., Yan H., Yamamoto S. High altitude and early childhood growth retardation: new evidence from Tibet. Eur J Clin Nutr. 2008;62(3):342–348.
69. Rannan-Eliya R.P., Hossain S.M., Anuranga C., Wickramasinghe R., Jayatissa R., Abeykoon A.T. Trends and determinants of childhood stunting and underweight in Sri Lanka. Ceylon Med J. 2013;58(1):10–18.
70. Bustamante A., Santos C., Pereira S., Freitas D., Katzmarzyk P.T., Maia J. Regional variation in growth status. The Peruvian health and optimist growth study. Am J Hum Biol. 2022;34(5):e23704.
71. Sanchez-Macedo L., Vidal-Espinoza R., Minango-Negrete J., Ronque E.V., Campos L.F.C.C., Fuentes-López J., Vargas-Ramos E., Rivera-Portugal M., Cossio-Bolaños M., Gomez-Campos R. Para-

meters of pubertal growth spurt in children and adolescents living at high altitude in Peru. J Pediatr (Rio J). 2024;100(2):189–195.
72. Cossio-Bolaños M.A., Vidal-Espinoza R., Minango-Negrete J., Olivares P.R., Urzua-Alul L., de Campos L.F.C.C., Fuentes-López J., Sanchez-Macedo L., Diaz-Bonilla E., Torres-Galvis C., Gomez-Campos R. Estimation of Pubertal Growth Spurt Parameters in Children and Adolescents Living at Moderate Altitude in Colombia. Front Endocrinol (Lausanne). 2021;12:718292.
73. Dolma P., Angchuk P.T., Jain V., Dadhwal V., Kular D., Williams D.J., Montgomery H.E., Hillman S.L. High-altitude population neonatal and maternal phenotypes associated with birthweight protection. Pediatr Res. 2022;91(1):137–142.
74. Weitz C.A., Garruto R.M. Stunting and the Prediction of Lung Volumes Among Tibetan Children and Adolescents at High Altitude. High Alt Med Biol. 2015;16(4):306–317.
75. Racine H.L., Serrat M.A. The Actions of IGF-1 in the Growth Plate and Its Role in Postnatal Bone Elongation. Curr Osteoporos Rep. 2020;18(3):210–227.
76. Sharma V., Varshney R., Sethy N.K. Human adaptation to high altitude: a review of convergence between genomic and proteomic signatures. Hum Genomics. 2022;16(1):21.
77. Santos C., Bustamante A., Katzmarzyk P.T., Vasconcelos O., Garganta R., Freitas D., Mirzaei-Salehabadi S., Maia J. Growth velocity curves and pubertal spurt parameters of Peruvian children and adolescents living at different altitudes. The Peruvian health and optimist growth study. Am J Hum Biol. 2019;31(6):e23301.
78. Martínez J.I., Figueroa M.I., Alfaro Gómez E.L., Dipierri J.E. Newborn anthropometry, maternal capital, and altitude in the highland population from the province of Jujuy, Argentina. Am J Phys Anthropol. 2021;175(1):25–35.
79. Potocka N., Skrzypa M., Zadarko-Domaradzka M., Barabasz Z., Penar-Zadarko B., Sakowicz A., Zadarko E., Zawlik I. Effects of the Trp64Arg Polymorphism in the *ADRB3* Gene on Body Composition, Cardiorespiratory Fitness, and Physical Activity in Healthy Adults. Genes (Basel). 2023;14(8):1541.
80. Potocka N., Penar-Zadarko B., Skrzypa M., Braun M., Zadarko-Domaradzka M., Ozimek M., Nizioł-Babiarz E., Barabasz Z., Zawlik I., Zadarko E. Association of *ACTN3* Polymorphism with Body Somatotype and Cardiorespiratory Fitness in Young Healthy Adults. Int J Environ Res Public Health. 2019;16(9):1489.
81. Mehata S., Shrestha N., Ghimire S., Atkins E., Karki D.K., Mishra S.R. Association of altitude and urbanization with hypertension and obesity: analysis of the Nepal Demographic and Health Survey 2016. Int Health. 2021;13(2):151–160.
82. Li X., Li Y., Xing X., Liu Y., Zhou Z., Liu S., Tian Y., Nima Q., Yin L., Yu B. Urban-rural disparities in the association between long-term exposure to high altitude and malnutrition among children under 5 years old: evidence from a cross-sectional study in Tibet. Public Health Nutr. 2023;26(4):844–853.
83. Maxfield A., Hadley C., Hruschka D.J. The relationship between altitude and BMI varies across low- and middle-income countries. Am J Hum Biol. 2024;36(5):e24036.
84. Абдуллозода С.М., Усманова Г.М., Гулбекова З.А. Маркеры окислительного стресса и антиоксидантной защиты при ожирении. Вестник последипломного образования в сфере здравоохранения. 2023b;3:5–13.
85. Абдуллозода С.М., Усманова Г.М., Кобилов К.К., Умарова З.А. Особенности обмена тиреоидных гормонов при ожирении. Вестник последипломного образования в сфере здравоохранения. 2023c;2:5–12.
86. Deshpande A., Ramachandran R. Early childhood stunting and later life outcomes: A longitudinal analysis. Econ Hum Biol. 2022;44:101099.
87. Robinson J.A., Dinh P.T.T. High doses of a national preschool program are associated with the long-term mitigation of adverse outcomes in cognitive development and life satisfaction among children who experience early stunting: a multi-site longitudinal study in Vietnam. Front Public Health. 2023;11:1087349.
88. Kulkarni S., Ramakrishnan U., Dearden K.A., Marsh D.R., Ha T.T., Tran T.D., Pachón H. Greater length-for-age increases the odds of attaining motor milestones in Vietnamese children aged 5-18 months. Asia Pac J Clin Nutr. 2012;21(2):241–246.
89. Tan S.Y., Poh B.K., Sekartini R., Rojroongwasinkul N., Tran T.N., Wong J.E., Novita Chandra D., Pongcharoen T., Tran K.V., Actis-Goretta L., Vonk M.M., Ng S.A., Parikh P., Khouw I., SEANUTS II Study Group. South East Asian Nutrition Surveys (SEANUTS) II — a multi-country evaluation of nutrition and lifestyle indicators in children aged 12 years and below: rationale and design. Public Health Nutr. 2024;27(1):e150.
90. Caulfield L.E., de Onis M., Blössner M., Black R.E. Undernutrition as an underlying cause of child deaths associated with diarrhea, pneumonia, malaria, and measles. Am J Clin Nutr. 2004;80(1):193–198.
91. Müller O., Krawinkel M. Malnutrition and health in developing countries. CMAJ. 2005;173(3):279–286.
92. Yang L.T., Wang N., Li Z.X., Liu C., He X., Zhang J.F., Han H., Wen Y.F., Qian Y.H., Xi H.J. Study on the adult physique with the Heath-Carter anthropometric somatotype in the Han of Xi'an, China. Anat Sci Int. 2016;91(2):180–187.
93. Sánchez-Macedo L., Vidal-Espinoza R., Gómez-Campos R., Díaz-Bonilla E., Torres-Galvis C.L., Urzua-Alul L., Castelli-Correia de Campos L.F., Sulla Torres J., Lee-Andruske C., Cossio Bolaños M. Physical growth of children and adolescents living at a moderate altitude: proposed percentiles based on age and sex. Nutr Hosp. 2021;38(6):1238–1247.
94. Wu S., Hsu L.A., Teng M.S., Chou H.H., Ko Y.L. Differential Genetic and Epigenetic Effects of the KLF14 Gene on Body Shape Indices and Metabolic Traits. Int J Mol Sci. 2022;23(8):4165.