I.M. Guseva[1], T.E. Borovik[1, 2], A.V. Surzhik[1], N.N. Semenova[1], A.G. Il'in[1,2], N.G. Zvonkova[1, 2], V.A. Skvortsova[1], O.L. Lukoyanova[1], T.V. Bushueva[1], T.N. Stepanova[1], E.K. Kutafina[1]

[1] Scientific Center of Children's Health, Moscow, Russian Federation

[2] Sechenov First Moscow State Medical University, Russian Federation

Evaluating the Physical Development and Nutrition of Children Aged 1–3 Living in Moscow

Author affiliation:

Tat'yana Eduardovna Borovik, PhD, Professor, head of the pediatric nutrition department at the Scientific Center of Children's Health

Address: 2/1 Lomonosovskiy Av., Moscow, 119991; **tel.:** +7 (499) 132-26-00; **e-mail:** borovik@nczd.ru

Irrational nutrition may results in physical and intellectual maldevelopment of children and reduction in body resistance to aggressive environmental factors. ***Study objective.*** *Assessment of physical development and nutrition of 1-3-year-old children living in Moscow.* ***Methods.*** *The authors examined 106 1-3-year-old children: group I (n = 59) was made up of 1-2-year-old children, group II (n = 47) – of 2-3-year-old children. Anthropometric data were evaluated with WHO software AnthroPlus; the authors calculated Z-score parameters: weight-for-age (WAZ), height-for-age (HAZ) and BMI-for-age (BAZ). Nutrition was assessed by reproducing a 3-day diet (actual diet) using software Dietplan 6. The authors analyzed the volume of the eaten food, the daily caloric content and the amount of consumed proteins, fats and carbohydrates.* ***Results.*** *Most examined children (76.4%) were characterized by age-medium parameters of physical development and nutrition (BAZ from -2 to +1). Excess body weight and obesity were observed in 1/5 of the children (BAZ > 1). In the children with excess body weight, especially in 1-2-year-old children, excessive consumption of food (by 200-300 g/day, $p < 0.001$), proteins (by 47.5%) and fats (by 36.7%), as well as excessive caloric content (by 21.3%, $p < 0.001$) were observed (in comparison with the recommended consumption standards).* ***Conclusion.*** *The identified nutritional disorders in 1-3-year-old children (overeating and unbalanced diet) result in excess body weight and even development of obesity. The children with high birth weight and high baseline BAZ score may be considered an obesity risk group. The BAZ score is the most informative parameter for a child's nutritive status assessment.*

Keywords: *infants, physical development, ANTHROPlus, Z-score, excess body weight, proteins, fats, carbohydrates, caloric content.*

(**For citing:** I.M. Guseva, T.E. Borovik, A.V. Surzhik, N.N. Semenova, A.G. Il'in, N.G. Zvonkova, V.A. Skvortsova, O.L. Lukoyanova, T.V. Bushueva, T.N. Stepanova, E.K. Kutafina. Evaluating the physical development and nutrition of children aged 1–3 living in Moscow. *Pediatricheskaya farmakologiya = Pediatric pharmacology*. 2015; 12 (3): 271–276. doi: 10.15690/pf.v12i3.1350)

RATIONALE

Physical development is an internal indicator of a child's health. It reflects the growth and development under ever-changing conditions of the habitat. The parameters of physical development are affected by age and innate predispositions as well as by ethnical and regional peculiarities, life style, environment, and diseases the child suffers or not [1, 2]. The importance attached to physical development is the reason why these parameters have been added to many information and analysis systems of social-hygienic and pediatric healthcare monitoring [3].

The key factors of harmonic physican and psychoemotional development of children include their nutrition. If a child's diet is unbalanced in terms of micronutrients and macronutrients, such imbalance may have both immediate and remote adverse effects on the child's physical and cognitive development, and may also weaken their resistance to aggressive environmental factors [4]. Improper nutrition affects children's physical development and health the most during the infancy and toddlerhood [5, 6]. The main criteria for physical development assessment are body weight and length (height for older-than-2 children), the thoracic circumference, the head circumference (for infants), as well as the ratios of these parameters. The child's motor skills and timely eruption of their deciduous teeth (for children under 2) are also in this list [7]. Each of these criteria has a meaning of its own and cannot be deemed a developmental marker if analyzed separately, i.e. without considering other factors in related thereto [8].

Body weight (the weight component) and size (the linear component) are thought to be the most stable parameters of physical development [9]. Individual anthropometric parameters are assessed by comparing them to age-appropriate values presented in percentile-based tables of height or as standard deviation curves [10]. Dynamic measurements allow to determine whether a child's development is harmonic and permanent, and if so, then to which extent. Knowledge of a child's physical development is needed not only to find out how well they grow and how well-nourished they are, but also to identify the body's capability of adapting to cognitive, emotional, physical, or psychological stress. Besides, these data can help predict future health issues, morbidity, mortality, cognitive development, labor capacity, reproductive function, and chronic diseases risks [11].

Infants' and toddlers' physical development and how it is affected by alimentary factors had not yet been assessed in a major city like Moscow with international standards applied, which is why this study was commenced. The **aim** of this study was to assess the physical development and nutrition of 1-to-3-year-old Muscovites.

METHODS

Research Design

The study was carried out as a part of the All-Russian Interregional Epidemiological Multicenter Research on the conditions of 1-to-3-year-old children, led by the experts affiliated with the Scientific Center of Children's Health, Russian Academy of Medical Sciences, and the Russian Medicine Academy of Post-Graduate Education.

The study was a cross-monitoring (one-step monitoring) study.

Fitting Criteria

Inclusion *criteria were as follows:*

- children should be healthy and belong to Group 1 and Group 2 of the health-based distribution;
- children should be 1-to-3-year-old;
- a child's birth weight should be 2,500 to 4,500g;
- a child should have had an Apgar score of ≥ 7 points at the first post-natal minute;
- parents should have agreed to take part in this study;
- they should also have signed a letter of informed consent so that children could be enrolled.

Exclusion criteria were as follows:

- therapeutic nutrition;

- any other factors, whether social or healthcare-related, that disrupted the usual dietary regimen and appetite of children; in an event of daily regimen changes (like admission to a kindergarten), a child would be excluded as well.

Research Conditions

The research was carried out at the basis of pediatric outpatient hospitals of Russia, namely State Budgetary Healthcare Institution City Pediatric Outpatient Hospital no. 149, Moscow, and the Pediatric Outpatient Hospital of the Department for Presidential Affairs of the Russian Federation, Moscow. It was conducted in compliance with European Good Clinical Practice Guidelines, 1991, and directives of the Healthcare Ministry of Russia.

Research Duration

The research was carried out from 2011 to 2013.

Research Methods

Assessment of physical development

The children's physical development was assessed under a standard checkup procedure, including an analysis of anthropometric parameters, i.e. height and weight. Body weight and height were assessed on a once-only basis. Body weight was measured using standard scales, body length (height) was measured using a standard height meter. The children's physical development was assessed in accordance to the WHO Height Standards of 2006, using ANTHROPlus software by the WHO. It helped calculate Z-score values.
- WAZ (Weight-for-Age Z-score, the normative range is -2SD to +2SD);
- HAZ (Height-for-Age Z-score, the normative range is -2SD to +2SD);
- BAZ (BMI-for-Age Z-score, the normative range is -2SD to +1SD);
In case indices were below normative values, we diagnosed underweight, a failure to thrive (WAZ <-2), a short stature (HAZ <-2) and/or insufficient nutrition (BAZ <-2). In case these values were above normative, we diagnosed excess body weight (WAZ>2; BAZ>+1, <+2), or obesity (WAZ >2; BAZ >2) and/or tall stature (HAZ >2).

Assessment of the Caloric Value of Nutrition

The calory value of children's nutrition was identified by applying Dietplan 6 (Forestfield Software Ltd., Great Britain). We calculated the daily consumption of main nutrients, with due account of age, sex, weight, physical activity, etc. We assessed the actual diet, a 3-day nutrition, with two days with the business day menu and a single day with a weekend menu. The values we thus gained were compared against reference values of nutrient consumption and food caloric content. The reference values were recommended in 1991 by the Committee of Medical Aspects of Food Policy. Nutrition standards recognized in Russia since 2008 were also taken into account {12 – 14]

Ethical Expertise

The research was approved by the Independent Interdisciplinary Committee for Ethical Expertise of Clinical studies (approvement no. 14, dd. September 30, 2011).

Statistical Data Processing

Data were processed statistically using STATISTICA v. 6.0 software suit by StatSoft Inc, USA. Quantitative parameters were described by means of arithmetic mean and standard error (M±m). Difference was deemed statistically significant if p was less than 0.05.

RESULTS

The study involved 106 1-to-3-year-old children.
Based on their age and consumption of nutritional substances and energy as deemed age-appropriate in Russia, the children were divided into two groups: Group I comprised 59 1-to-2-year-old children, Group II comprised 47 2-to-3-year-old children [15]. In this population, 54.7% were boys and 45.3% were girls.
In general, the two groups did not differ significantly in birth weight and Apgar score. In Group II, birth weight of boys was slightly greater than that of girls (p=0.039), see Table 1).

Table 1. **Birth weight and Apgar score**

Parameter	**Group I (n=59)**		**Group II (n=47)**	
Gender	boys (n=25)	girls (n=34)	boys (n=24)	girls (n=23)
Weight: birth weight, g	3429.3±95.8	3420.3±63.4	3630.4±84.2*	3401.1±75.4
group's average, g	3424.1±54.1		3518.2±58.5	
Apgar score	8.6±0.1	8.6±0.1	8.5±0.1	8.6±0.1

Note: * – p <0,039 (significance of difference in boys' and girls' values)

An assessment of somatometric parameters identified that in Group I, the average body weight at the time of this study was 11,5±0,2 kg, the height was 82,8±0,6 cm; in Group II, the values were 13,6±0,2 kg, 93,2±0,6 cm. In both age-based groups, weight and height values were age-appropriate and corresponded to age-average values, whereas boys were statistically significantly higher than girls, though did not differ significantly in weight (Table 2).

Table 2**. Physical development parameters of studied 1-to-3-year-old children (M±m)**

Parameter	**Group I (n=59)**		**Group II (n=47)**	
Gender	boys (n=25)	girls (n=34)	boys (n=24)	girls (n=23)
Age in months	17.0±0.7	16,8±0,5	29.6±0.6	29.2±0.7
	16.9±0.4		29,4±0,5	
Height in cm	84.2±0.9*	81,8±0,8	94.5±0.8**	91.8±0.7
	82.8±0.6		93,2±0,6	
Body weight in kg	11.9±0.2	11.2±0,2	14.1±0.3	13.2±0.2
	11.5±0.2		13,6±0,2	
WAZ	0.47±0.04			
HAZ	0.54±0.05			
BAZ	0.4±0.08			

Note: * – p=0,043; **– p=0,015 (significance of difference in boys' and girls' values)

As seen from Table 2, average Z-score was positive for all the children: WAZ amounted to 0,47±0,04, HAZ to 0,54±0,05, BAZ to 0,4±0,08. At the same time, the studied Z-score values fluctuated rather significantly.

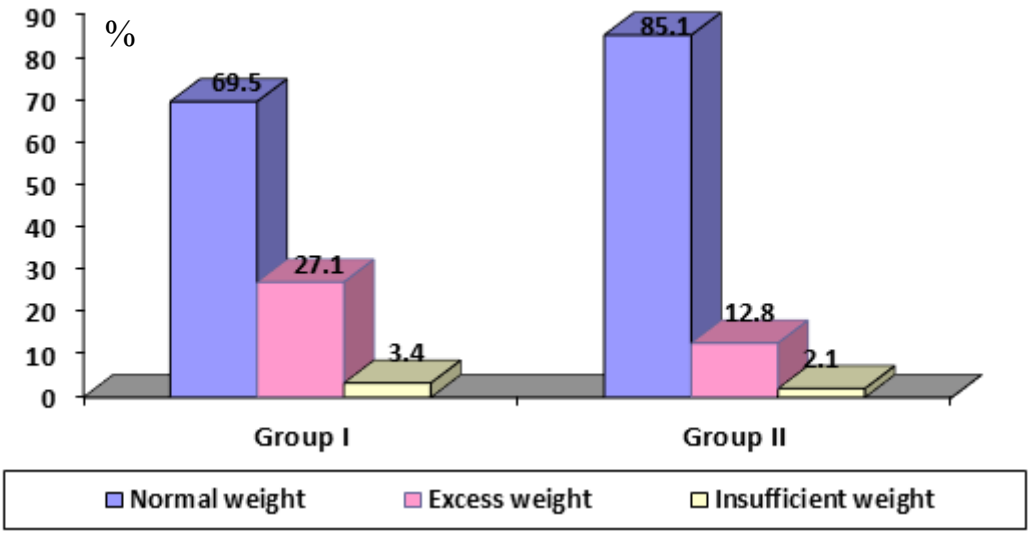
Depending on the Z-score interpretation (see Table 1), it was found out that WAZ was within the permissible range (-2 to +2) for most children (56, or 94.9%) of Group I, and for all the children of Group II. Insufficient body weight (WAZ <-2) was not identified in any child. Excess body weight (WAZ > +2) was noted for 3 (5.1%) children of Group I (Table 3).
HAZ calculations showed that most children of both groups (89 cases, 83.9%) had a HAZ within the permissible range (-2 to +2). 49 (83%) children of Group I had a height within the normative range; the same applies to 40 (85.1%) children of Group II. Short stature (HAZ <-2) noted for 2 children (3.4%) of Group I. Tall stature (HAZ > +2) noted for 8 (13.6%) children of Group I, 7 (14.9%) children of Group II (see Table 3).

Table 3. Z-score of studied 1-to-3-year-old children

Z-score		< -2	-2 to -1	-1 to +1	+1 to +2	> +2
		Total number of children in Group I (n=59), absolute and %				
WAZ (body weight for age)	n	0	1	33	22	3
	%	0	1.7	55.9	37.3	5.1
HAZ Height for Age	n	2	1	23	25	8
	%	3.4	1.7	38.9	42.4	13.6
BAZ BMI for Age	n.	2	5	36	13	3
	%	3.4	8.5	61.0	22.0	5.1
Z-score		Total number of children in Group II (n=47), absolute and %				
WAZ (body weight for age)	n	0	3	35	9	0
	%	0	6.4	74.5	19.1	0
HAZ Height for Age	n	0	1	33	6	7
	%	0	2.1	70.2	12.8	14.9
BAZ BMI for Age	n	1	9	31	5	1
	%	2.1	19.2	65.9	10.6	2.1

BAZ was within the permissible range (-2 to +1) in most children, i.e. 81 (76.4%). For Group I, the number was 41 (69.5%), for Group II, it was 40 (85.1%). Insufficient nutrition (BAZ <-2) was diagnosed only for 2 (3.4%) children of Group I, 1 (2.1%) child of Group II. Excess body weight (BAZ of +1 to +2) was identified only in 18 children (BAZ 1,6±0,5). 13 of them (22.0%) belonged to Group I, 5 (10.6%) belonged to Group II (Fig. 1). For four children (3 of Group I, 1 of Group II), BAZ was >2 (the exact values were 2,18; 2,24; 2,68; 2,82), see Table 3.

Fig. 1. Percentage distribution of studied children based on their age and BAZ



The parameters of children's physical development depending on their BAZ are shown in Table 4.

Table 4. Anthropometric parameters of children with different BAZ values, M±m

Parameters	Group I (1-to-2-year-old)			Group II (2-to-3-year-old)		
BAZ	**< -2**	**-2- +1**	**>1**	**< -2**	**-2- +1**	**>1**
Absolute value	2	41	16	1	40	6
Boys (m) Girls (f)	1 1	14 27	10 6	1 0	19 21	4 2
Value of birth weight, g	m 2.750 f 3.830	3366.9±59.1	3587.3±113.7*	2780	3488.6±60.9	3838.3±117.3**
Body weight when studied, kg	m 12.1 f 12.0	11027.3±165.8	12711.9±228.1	1050	13406±167.7	15525±832.0
Height when studied, cm	m 95 f 94.5	82.3±0.7	82.7±1.1	92	93.3±0.6	92.5±1.9
WAZ	m. 1.11 f 1.21	0.56±0.1	1.46±0.2***	-1.29	0.3±0.1	1.52±0.2***
HAZ	m 4.73 g 4.83	1.0±0.1	0.59±0.3	1.57	0.7±0.2	0.57±0.2

Note: * – p =0,049; ** – p=0,019 (significance of difference from the group with normal BAZ values); *** – p<0,001 (significance of difference from the group with normal WAZ values)

In Table 4 above, it is attention-worthy that in both age-based groups, children with excess weight (BAZ>1) had a weight that quite significantly exceeded that of children with average BAZ values, as of the study time (p=0.0049 and p=0.019).

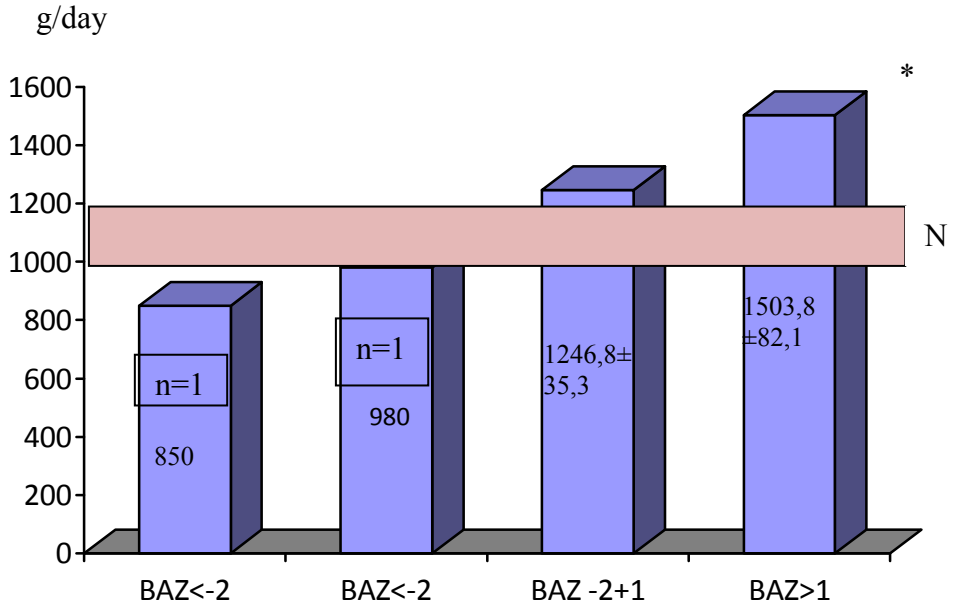
Average height and weight values as well as WAZ and HAZ values (M±m) in both age-based groups were within the reference range despite BAZ difference. However, WAZ in excessively-weighing children (BAZ >1) was significantly higher in both Group I and Group II (2.6 and 5 times higher, respectively). No significant HAZ difference in children of various nutritional status was identified. The obtained results confirm that BAZ should be used to identify insufficient nutrition or excess body weight in infants and toddlers.

Individual assessment of children with BAZ <-2 (3 children overall, 2 in Group I and 1 in Group II) showed that their birth weight was within the reference range: 2750, 3830, and 2780 g (see Table 4). At the same time, those children were rather tall.

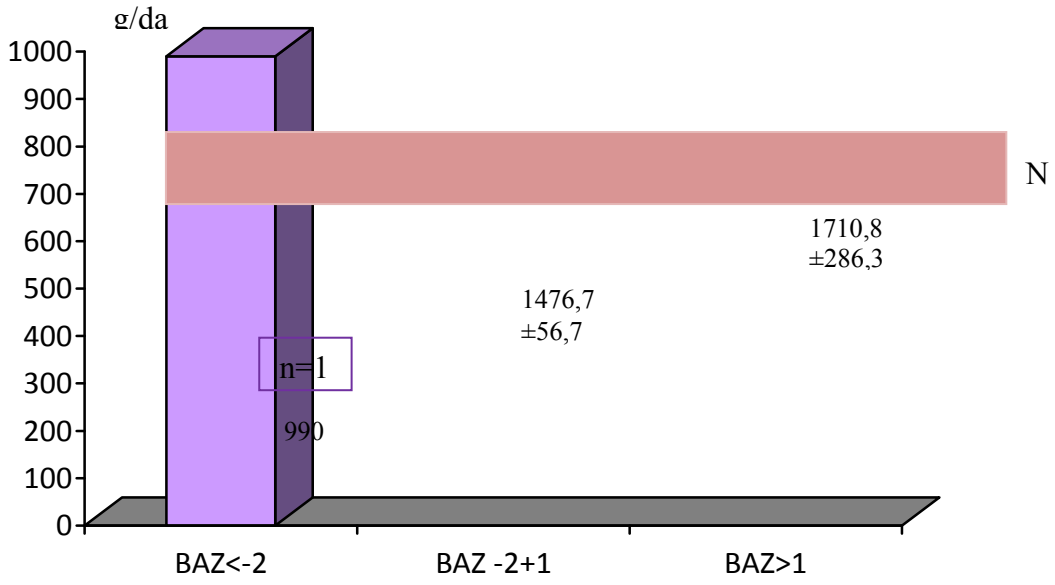
An analysis of daily food consumption in Group I showed that in Group I, food consumption of excessively weighing children was above the recommended values (1,000 to 1.200 g per day)

and significantly ($p<0.001$) higher than that of children with normative nutritional status (Fig. 2, a, b).

Fig. 2. Daily Food Consumption (g per day)



a) 1-to-2-year-old children *$p>0.001$ significance in relation to the recommended values



b) 2-to-3-year-old children

In Group II, despite no significant difference, daily food consumption of excessively weighing children exceeded the recommended amounts (1.200 to 1,500 ml per day) just like in Group I and was considerably greater than that of normally weighing children (see Fig. 2 b) Food consumption of children with excess BAZ increased due to non-compliance with the dietary regimen, i.e. increased portions, frequent food intakes between regular meals, and night-time feeding.

For the three children with reduced nutritional status, daily food consumption was below the recommended values (850 to 990 g per day).

Due to the small number of underweighing children, we will further dwell upon a comparative analysis of nutritional and caloric value of nutrition of normally weighing and excessively weighing children (Table 5).

Table 5. Chemical composition of nutrition of studied children with different BAZ values (M±m) [16]

Parameters	**RSN** [1]	**Group I (1-to-2-year-old)**		**RSN**	**Group II (2-to-3-year-old)**	
BAZ		**-2+1 (n=41)**	**>1 (n=16)**		**-2+1 (n=40)**	**>1 (n=6)**
Proteins, g/day	36	45.5±1.8	53.1±2.9**	42	56.4±2.8	59.3±8.6
Fats, g/day	40	46.5±2.9	54.7±2.9*	47	55.4±2.3	53.8±7.3
Carbohydrates, g/day	174	153.8±1.8	184.1±8.45 *	203	194.8±6.1	202.1±19.6
Caloric value, kcal/day	1.200	1.232±29. 4	1.456±43.0 *	1.400	1.507±43. 7	1.548±176. 7

Note: [1]RSN stands for Recommended Standards of Physiological Needs in Energy and Nutritives for different population groups in Russia, MR 2.3.1.2432-08, approved on December 18th, 2008. . – p <0,001,. – p =0,092 (significance of difference between normally weighing and excessively weighing children).

In younger children with BAZ of -2 +1, daily protein consumption exceeded the recommended values by 26.4%, fat consumption exceeded the recommended values by 16.3%, and carbohydrate consumption was 11.6% below the recommended values. The caloric value of daily

food intake was within the normative range. As of excessively weighing children (BAZ>1), excessive protein and fat consumption was more evident during the second post-natal year. Considering the average values (M±m), it exceeded the recommended daily consumption values by 47.5% and 36.7%, respectively. Carbohydrate consumption was close to age-appropriate levels. The caloric value of their daily food intake was 21.3% higher than recommended. A comparison of the nutritional and caloric value of daily food intake in the analyzed group revealed that the caloric content of excessively weighing children was significantly greater ($p<0.001$) as compared to normally weighing children, whereas the former consumed more fats and proteins ($p=0.092$) as well as more carbohydrates ($p<0.001$).

In Group II, the nutritional and caloric value of daily food intake was similar for both normally and excessively weighing children. Protein consumption exceeded the normative values by 34.3% and 41.2%, respectively, fat consumption exceeded the normative values by 17.8% and 14.5%, carbohydrate consumption was close to the normative values. The caloric value exceeded the norm by 7.6 to 10.6 percent, which was not significant. The obtained results did not allow to identify a significant impact of the nutritional and caloric value of food on the nutritional status of children in their third post-natal year, which is where they differ from children in the second post-natal year. This may be due to the insufficient number of monitoring studies.

DISCUSSION

In general, average Z-score values (body weight for age, height for age, and BMI for age) of the studied children were positive and within the permissible fluctuation range, which proved the development of most young Muscovites was harmonic and balanced [1, 2]. At the same time, the studied Z-score values fluctuated rather significantly.

In most (76.4%) of those children, BAZ (BMI-for-Age Z-score), which indicates the nutritional status, was within the permissible fluctuation range (-2 to +1). Excess body weight (BAZ +1 and >2) was identified in 22 (20.8%) studied children. The number of children with BAZ>1 in the second post-natal year was more than twice as high as that of such children in the third post-natal year, which is probably due to increasing physical and cognitive activities of older children, who attend special sports classes and developmental courses.

Based on BMI-for-Age Z-score (BAZ <-2), insufficient nutrition was identified only for 3 children (2.8%) and was most likely due to their tall stature.

HAZ (Height-for-Age) was within the normative range (-2 to +2) for most children in both groups (83.9%). 83.1% of children in Group I had a normal height; the same applies to 85.1% of children in Group II. Short stature (HAZ <-2) was noted for 3.4% of children in Group I. Tall stature (HAZ >+2) was diagnosed in 14.2% of children older-than-2. Such children made up for 13.6% of Group I, 14.9% of Group II. It can be seen as a reflection of developmental acceleration and constitutional peculiarities of the today's children.

Food intake of 1-to-2-year-old excessively weighing children was above the recommended values and significantly ($p<0.001$) higher than that of children with normal nutritional status [12, 13]. A similar trend could be observed in older children. An analysis of survey data showed that food intake of excessively weighing (BAZ>1) children was mostly due to non-compliance with the dietary regimen, i.e. increased portions, frequent food intakes between regular meals, and night-time feeding.

The nutrition of excessively weighing (BAZ>1) children, especially in the younger group was distinguished by excessive caloric value and overconsumption of proteins (1.5 times as high) and fats (1.4 times as high) as compared to the recommended values. The caloric content of daily food intake of excessively weighing children in their second post-natal year was significantly ($p \square 0.001$) greater compared to normally weighing children; the former also consumed more food proteins and fats ($p=0.092$).

It is attention-worthy that children with normal nutritional status (BAZ -2+1) also consumed more proteins and fats per day as recommended. However, the caloric value of their daily food intake did not exceed the recommended values due to low carbohydrate consumptions [12].

CONCLUSION

The study carried out in Moscow showed that the physical development of 1-to-3-year-old children is directly affected by excessive food, protein, and fat consumption, and therefore excessive caloric value of daily food intake. Overeating and imbalanced nutrition lead to excess body weight. For nutritional status assessment, BAZ is the most informative indicator, as it allows to compare a child's weight against their height and age.

RESEARCH LIMITATIONS

Standardization and faultnessness of measurement equipement. Correctness and truthfulness of parent-provided survey data, the sincerity of parents who answered the questionnaire.

CONFLICT OF INTEREST

The authors of this article have declared absence of reportable financial support / conflict of interest.

REFERENCES

1. A.A. Baranov, L.A. Shcheplyagina. Fundamentalnye i prikladnye issledovaniya po problemam rosta i razvitiya detey i podrostkov. *RPZ.* 2000; 5: 5-12.
2. Z.G. Chizhova. Physical and neuropsychic development of infants born to young and mature mothers. PhD in Biology: thesis. 03.00.13. Moscow, 2007. 208 p.
4. I.Z. Zakharova, E.B. Machneva. Impact of micronutrients on cognitive development of children. *Pediyatriya. Appendix to journal "MediaMedika".* 2014; 2: 16-20.
6. A.A. Ploskireva, S.V. Nikolayeva. Rol obogashchennykh produktov pitaniya v formirovaniyi zdorovya detey. *Pediyatriya.* 2011; 91 (6): 59-63.
7. Guidelines on ambulatory/polyclinic pediatrics. Ed. by A.A. Baranov. 2nd issue, revised and updated. *Moscow: GEOTAR-Media.* 2009. 592 p.
9. Feeding and nutrition of infants and young children. Guidelines for the WHO European Region with emphasis on the former Soviet countries. 2003. 288 p.
10. Preventive pediatrics: guidelines for physicians. Ministry of Health of the Russian Federation [et al.]. Ed. by A.A. Baranov, L.S. Namazova-Baranova. *Moscow: Pediyatr.* 2015. 744 p.
11. E.M. Bulatova, N.M. Bogdanova, I.S. Volkova, D.G. Penkov. Fizicheskoye razvitiye i sostoyaniye pitaniya detey rannego vozrasta, nakhodyashchikhsya v uchrezhdeniyakh zakrytogo tipa. *Meditsinskiy sovet.* 2012; 6: 64-68.
12. Specialized foodstuffs for children with various pathologies: Catalogue. Ed. by T.E. Borovik, K.S. Ladodo, V.A. Skvortsvoa. *Moscow.* 2012. 184 p.
13. The Chemical Composition and Energy of Foods. 6th issue. Manual ed. by McCance and Widdowsone. Translated from English. *Saint Petersburg: Professiya.* 2006. 416 p.
14. Tekhnologicheskaya instruktsiya po proyizvodstvu kulinarnoy produktsiyi dlya pitaniya detey i podrostkov shkolnogo vozrasta v organizovannykh kollektivakh. Moskovskiy fond sodeystviya sanitarno-epidemiyologicheskomu blagopoluchiyu naseleniya. *Moscow.* 2006.
15. Guidelines for social pediatrics. Ed. by V.G. Dyachenko. *Khabarovsk: Izdatelstvo GOU VPO DGMU.* 2010.
16. Norms of physiological demand of energy and nutrients of different population groups of the Russian Federation. MR 2.3.1.2432-08. Approved on December 18, 2008.