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Features of the physical development and sociodemographic status of preschool children living in areas contaminated with radioactive substances and affected by iodine deficiency

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Aim – to assess the anthropometric and sociodemographic indicators of preschool-age children living in the territories of the Kyiv region exposed to radioactive contamination (RCT) and characterized by iodine deficiency, and to analyze the relationship between socio-economic status and physical development.
Materials and methods. A total of 355 preschool-aged children (1–6 years) from the RCTs of the Ivankiv district, Kyiv region, and Kyiv city were examined. The studies were conducted in the winter-spring and summer-autumn periods. Anthropometric measurements (body length/weight, chest circumference (CC) were assessed using the sigma method. Sociodemographic data were collected through parental surveys. Statistical analysis was performed using Student's t-test.
Results. The physical development of most children corresponded to average age norms. However, children living in the RCTs showed a statistically significant disparity in physical development, as evidenced by a significantly smaller CC compared to children in Kyiv. An analysis of sociodemographic indicators revealed that the average monthly income of families living in the RCTs was 2.3 times lower, and mothers predominantly had secondary or secondary vocational education.
Conclusions. Imbalanced (disharmonious) physical development of children from the RCTs' rural areas may be associated with unfavorable socioeconomic factors, particularly low parental income and education. These findings highlight the importance of considering social factors when assessing the health status of children in ecologically disadvantaged regions.
The authors declare no conflict of interest.
Keywords: physical development, radioactively contaminated territories, sociodemographic status, preschool children, anthropometry.

Особливості фізичного розвитку та соціально-демографічного статусу дітей дошкільного віку, які проживають на радіоактивно забруднених та йододефіцитних територіях

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Мета – дослідити антропометричні та соціально-демографічні показники дітей дошкільного віку, які проживають на радіоактивно забруднених (РЗТ) та йододефіцитних територіях Київської області, проаналізувати зв'язок між соціально-економічним статусом та фізичним розвитком.
Матеріали і методи. Обстежено 355 дітей дошкільного віку (1–6 років) із РЗТ Іванківського району Київської області та м. Києва. Дослідження проводили в зимово-весняний та літньо-осінній періоди. Антропометричні вимірювання (довжина/маса тіла, окружність грудної клітки) оцінено за сигмальним методом. Соціально-демографічні дані отримано за допомогою анкетування батьків. Статистичний аналіз охоплював t-критерій Ст'юдента.
Результати. Встановлено, що фізичний розвиток більшості дітей відповідав середнім віковим нормам. Однак у дітей, які проживають на РЗТ, виявлено статистично значущу дисгармонійність фізичного розвитку, що простежується в достовірно меншій окружності грудної клітки порівняно з дітьми з м. Києва. Аналіз соціально-демографічних показників показав, що сім'ї на РЗТ мали у 2,3 разу нижчий середньомісячний дохід, а матері – переважно середню та середню спеціальну освіту.
Висновки. Дисгармонійний фізичний розвиток дітей із РЗТ може бути пов'язаний із несприятливими соціально-економічними факторами, зокрема з нижчим рівнем доходу та освіти батьків. Отримані результати наголошують на важливості врахування соціальних чинників для оцінки та формування стану здоров'я дитячого населення в регіонах з екологічними проблемами.
Автори заявляють про відсутність конфлікту інтересів.
Ключові слова: фізичний розвиток, радіоактивно забруднені території, соціально-демографічний статус, діти дошкільного віку, антропометрія.

The National Program «Health 2020: Ukrainian Dimension» considers disease prevention and healthy lifestyle promotion as key vectors of state healthcare policy. According to the World Health Organization (WHO), human health depends by 50–55% on lifestyle and living conditions, and by 25% on environmental conditions [9]. These data emphasize that social status and access to quality resources, particularly adequate nutrition, are critically important for children's health.

The health of children living in areas affected by the Chernobyl disaster is particularly compromised. In these regions, in addition to radiation exposure, unfavorable socioeconomic conditions and iodine deficiency are common, which can have a negative synergistic effect on health [4,9].

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Table 1

Number of children examined

Gender	Age	Ivankiv District, Zone III (n=48)	Ivankiv District, Zone IV (n=50)	Kyiv City (n=103)
Summer–Autumn period (n=201)				
Boys	1–3 years	12 (25.0%)	10 (20.0%)	23 (22.3%)
	4–6 years	9 (18.8%)	12 (24.0%)	23 (22.3%)
Girls	1–3 years	12 (25.0%)	13 (26.0%)	28 (27.2%)
	4–6 years	15 (31.3%)	15 (30.0%)	29 (28.2%)
Winter–Spring period (n=154)				
		Ivankiv District, Zone III (n=48)	Ivankiv District, Zone IV (n=52)	Kyiv City (n=54)
Boys	1–3 years	12 (25.0%)	10 (19.2%)	13 (24.1%)
	4–6 years	11 (22.9%)	13 (25.0%)	14 (25.9%)
Girls	1–3 years	13 (27.1%)	13 (25.0%)	15 (27.8%)
	4–6 years	12 (25.0%)	16 (30.8%)	12 (22.2%)

The aim of the work was to assess the anthropometric and sociodemographic indicators of preschool children living in the radioactively contaminated territories (RCT) of the Ivankiv district of the Kyiv region (III and IV radiation control zones) and in the city of Kyiv, as well as to analyze the relationship between these indicators.

Materials and methods of the study

The study included 355 preschool-aged children (193 girls and 162 boys). They were divided into age groups: 174 children aged 1–3 years and 181 – aged 4–6 years.

A detailed distribution by gender, age, place of residence and survey period is presented in Table 1.

The study was conducted using the principles of comparative ecological, hygienic, and social analysis. The sample was randomly selected from children attending preschool educational institutions in the respective regions. All children examined were divided into two main groups based on the radioecological status of their place of residence and the level of urbanization.

The Main group (children from the RCT, n=198): children permanently residing in rural settlements of the Ivankiv district of the Kyiv region, which, according to the current classification, are assigned to Zone III (Zone of guaranteed voluntary resettlement, n=97) and Zone IV (Zone of enhanced radioecological monitoring, n=101) of radioactive contamination as a result of the Chernobyl accident, and reside in an area endemic for iodine deficiency.

Control group (Kyiv, n=157): children living in a metropolitan area with a relatively favorable radioecological status and centralized socioeconomic support.

To exclude subjective errors and account for seasonal dietary factors (the availability of local fresh produce, vegetables, and fruits, as well as seasonal variations in dietary micronutrient levels), hygiene monitoring and anthropometric measurements were conducted during two key calendar periods:

Summer-fall period (n=201 children): during this phase, mass screening of children was conducted during the period of maximum solar insolation and the greatest natural availability of a variety of fresh, local plant foods. This allowed for an assessment of physical development parameters against the backdrop of potentially optimal seasonal nutritional support.

Winter–spring period (n=154 children): repeated and parallel observation was carried out under conditions of natural seasonal depletion of the body's internal bioresources, a deficiency of solar radiation (risk of hypovitaminosis D) and a systematic decrease in the consumption of fresh fruits and vegetables, which is crucial for assessing the stability of somatogenesis under the chronic influence of micronutrient deficiency and radioecological pressure.

Inclusion criteria for the study: age from 1 to 6 years inclusive, permanent residence in the specified territory (at least 1 year), written informed consent of parents or legal representatives for somatometric examination and questionnaires, as well as the absence of signs of acute infectious, somatic, or exacerbated chronic diseases at the time of examination.

A comprehensive hygiene study was conducted directly in preschool educational institutions in the Ivankiv district and the city of Kyiv in several sequential stages according to a single standardized scheme.

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Table 2

Social characteristics of the mothers of the children surveyed (355 mothers)

Sociodemographic Indicators	Ivankiv District (RCT), n=198	Kyiv City, n=157
Mother's marital status		
Unmarried / Single	26 (13.1%)	7 (4.5%)*
Married	158 (79.8%)	145 (92.4%)*
Divorced	14 (7.1%)	5 (3.1%)
Number of children in the family		
One	11 (5.6%)	50 (31.9%)*
Two	178 (89.9%)	90 (57.3%)*
Three or more	9 (4.5%)	17 (10.8%)*
Mother's education level		
Incomplete secondary	7 (3.5%)	0 (0.0%)
Secondary	132 (66.7%)	23 (14.6%)*
Specialized secondary / Vocational	46 (23.2%)	60 (38.2%)*
Student	9 (4.6%)	15 (9.6%)
Higher (University degree)	4 (2.0%)	57 (36.3%)*

Note: * – differences between groups are statistically significant ($p<0.05$).

Preparatory stage: obtaining official permission from the institution administrations and collecting written informed consent from parents. Formation of representative groups of children matched by age and gender.

Questionnaire and survey stage: conducting a sociological screening of families. Parents completed specialized, standardized questionnaires covering several indicators: marital status, number of children in the family, mother's education level, and average monthly total income per family member.

Anthropometric stage: individual somatometric measurements were taken in the morning in specially equipped medical rooms. Standing height was measured using a standard vertical wooden stadiometer (accurate to 0.5 cm), body weight was measured using a calibrated electronic medical scale (accurate to 50 g), and was measured using an elastic centering tape (accurate to 0.1 cm).

Analytical and evaluation stage: the obtained primary anthropometric data were compared with current regional age and gender standards. Calculation of individual sigma deviations (σ) allowed children to be classified into physical development groups (harmonious/disharmonious; average, above average, or below average).

Statistical stage. Mathematical processing of digital data sets, including verification of the distribution type and calculation of significance criteria for differences between groups.

Statistical analysis. Statistical processing of the obtained data was performed using SPSS Statistics 25.0. Data were tested for normal distribution using the Kolmogorov-Smirnov test. Normally distributed indicators were presented as the mean (M), standard error of the mean (m), and standard deviation (SD/σ). The statistical significance of differences between groups was assessed using Student's t-test. A significance level of $p<0.05$ was considered statistically significant.

Results of the study and discussion

Sociodemographic characteristics of families. An analysis of the social status of the mothers of the children surveyed revealed significant differences depending on place of residence (Table 2).

The study found that in Ivankiv district, the proportion of women legally married was 79.8%, while in Kyiv this figure reached 92.4% ($p<0.05$). Moreover, the proportion of single mothers in rural areas within the RCTs was significantly higher, accounting for 78.9% of all unmarried women in the study.

As for the number of children in the family, 89.9% of families in the RCTs had two children, while in Kyiv, 57.3% had two children, and 31.9% had only one child. This may indicate that families with two children and larger intact families are more common in rural areas.

The most pronounced discrepancy was found in maternal education. Among women living in the RCTs, the vast majority (66.7%) had only a general secondary education, and only 2.0% of mothers had higher education. In contrast, in Kyiv, a third of mothers (36.3%) had higher education.

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Table 3

Physical development of examined children aged 1 to 3 years (174 children)

Characteristic	Place of residence	M±m	σ	Sigma deviation	Physical development group
Summer–Autumn Period (98 children)					
Boys (45 children)					
Standing body length, cm	Zone III, n=12	91.2±2.6	8.5	0.18	average
	Zone IV, n=10	91.4±2.4	8.5	0.21	average
	City, n=23	94.0±2.2*	10.3	0.42	average
Recommended values 89.6					
Body mass, kg	Zone III, n=12	13.2±0.8	2.8	-0.142	average
	Zone IV, n=10	14.0±1.0	3.2	0.125	average
	City, n=23	14.3±0.7	3.2	0.21	average
Recommended values 13.6 kg					
Chest circumference, cm	Zone III, n=12	48.0±1.0*	3.3	-1.33	below average
	Zone IV, n=10	49.0±0.9*	3.2	-1.1	below average
	City, n=23	50.9±0.9	4.2	-0.4	average
Recommended values 52.4					
Girls (53 children)					
Standing body length, cm	Zone III, n=12	90.2±3.0	10.1	0.07	average
	Zone IV, n=13	90.4±2.4	8.8	0.1	average
	City, n=28	92.8±1.8	9.45	0.4	average
Recommended values 89.5					
Body mass, kg	Zone III, n=12	12.9±0.8	2.8	-0.3	average
	Zone IV, n=13	13.0±0.7	2.4	-0.3	average
	City, n=28	13.9±0.5	2.61	0.1	average
Recommended values 13.6					
Chest circumference, cm	Zone III, n=12	47.0±1.1*	3.8	-1.5	below average
	Zone IV, n=13	47.3±0.9*	3.6	-1.5	below average
	City, n=28	51.5±0.9	4.44	-0.3	average
Recommended values 52.7					
Winter–Spring Period (76 children)					
Boys (35 children)					
Standing body length, cm	Zone III, n=12	93.3±2.5	8.7	0.4	average
	Zone IV, n=10	92.7±2.7	8.9	0.3	average
	City, n=13	92.2±1.8	8.48	0.3	average
Recommended values 89.6					
Body mass, kg	Zone III, n=12	14.3±1.0	3.2	0.2	average
	Zone IV, n=10	14.3±1.1	3.6	0.1	average
	City, n=13	14.0±0.4	1.98	0.2	average
Recommended values 13.6					
Chest circumference, cm	Zone III, n=12	46.9±1.1*	3.8	-1.4	below average
	Zone IV, n=10	46.9±1.1*	3.6	-1.7	below average
	City, n=13	51.1±0.9	4.09	-0.3	average
Recommended values 52.4					
Girls (41 children)					
Standing body length, cm	Zone III, n=13	92.3±3.1	11.2	0.2	average
	Zone IV, n=13	93.2±3.0	11.3	0.3	average
	City, n=15	91.1±1.9	9.97	0.2	average
Recommended values 89.5					
Body mass, kg	Zone III, n=13	13.6±1.0	3.2	0	average
	Zone IV, n=13	13.6±0.8	3.1	0	average
	City, n=15	13.6±0.4	2.3	0.01	average
Recommended values 13.6					
Chest circumference, cm	Zone III, n=13	47.0±1.1	4.0	-1.4	below average
	Zone IV, n=13	47.0±1.0	3.8	-1.5	below average
	City, n=15	52.0±0.6	3.03	-0.23	average
Recommended values 52.7					

Note: * – the difference between the studied groups of children and the recommended values is statistically significant (p<0.05).

Table 4

Physical development of examined children aged 4 to 6 years (n=181)

Parameter	Place of residence	M±m	σ	Sigma deviation	Physical development group
Summer–autumn period (103 children)					
Boys (44 children)					
Standing body length, cm	Zone III, n=9	106.8±4.8	14.0	-0.1	average
	Zone IV, n=12	108.4±3.6	10.6	0.01	average
	city, n=23	108.5±3.5	15.03	0.01	average
Recommended values: 108.3					
Body weight, kg	Zone III, n=9	19.5±1.9	5.6	0	average
	Zone IV, n=12	20.1±5.6	5.6	0.1	average
	city, n=23	21.9±1.8	7.7	0.3	average
Recommended values: 19.5					
Chest circumference, cm	Zone III, n=9	54.6±0.8	2.2	-1.0	below average
	Zone IV, n=12	54.8±0.7	2.0	-1.1	below average
	city, n=23	56.9±0.5	1.9	0	average
Recommended values: 52.4					
Girls (59 children)					
Standing body length, cm	Zone III, n=15	107.0±2.8	10.8	-0.2	average
	Zone IV, n=15	108.5±1.5	6.0	-0.03	average
	city, n=29	110.8±1.7	9.7	0.2	average
Recommended values: 108.7					
Body weight, kg	Zone III, n=15	18.8±1.0	3.9	-0.4	average
	Zone IV, n=15	18.9±0.9	3.5	-0.5	average
	city, n=29	23.3±0.5	6.3	0.4	average
Recommended values: 20.5					
Chest circumference, cm	Zone III, n=15	53.3±0.8*	2.9	-0.9	average
	Zone IV, n=15	53.5±0.6*	2.5	-0.9	average
	city, n=29	57.5±0.9*	3.4	0.5	average
Recommended values: 55.8					
Winter–Spring Period (78 children)					
Boys (38 children)					
Standing body length, cm	Zone III, n=11	107.8±4.0	16.7	-0.03	average
	Zone IV, n=13	112.1±2.4	8.6	0.4	average
	city, n=14	108.2±3.1	14.7	0	average
Recommended values: 108.3					
Body weight, kg	Zone III, n=11	20.7±1.3	4.3	0.3	average
	Zone IV, n=13	23.4±4.1	15.4	0.2	average
	city, n=14	19.9±0.9	4.3	0.1	average
Recommended values: 19.5					
Chest circumference, cm	Zone III, n=11	55.0±0.6	2.1	-0.9	average
	Zone IV, n=13	55.6±0.5	2.0	-0.7	average
	city, n=14	56.6±0.6	2.65	0.1	average
Recommended values: 56.9					
Girls (40 children)					
Standing body length, cm	Zone III, n=12	109.5±4.7	16.7	0.1	average
	Zone IV, n=16	109.9±2.1	7.7	0.2	average
	city, n=12	105.6±1.9	9.86	-0.3	average
Body weight, kg	Zone III, n=12	22.4±1.9	6.6	0.3	average
	Zone IV, n=16	24.8±1.7	6.5	0.7	average
	city, n=12	18.4±0.4*	3.91	-0.5	average
Recommended values: 20.5					
Chest circumference, cm	Zone III, n=12	53.1±1.3	4.7	-0.6	average
	Zone IV, n=16	53.3±1.0	3.6	-0.7	average
	city, n=12	53.3±0.6*	2.37	-1.0	average
Recommended values: 55.8					

Note: * – the difference between the groups of examined children and the recommended values is statistically significant, p<0.05.

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The described educational gradient directly impacts the level of material security of families: the average monthly aggregate income of families in rural areas was 2.3 times lower than that of Kyiv households ($p<0.05$). This limiting factor significantly limits the rural population's ability to purchase healthy and varied foods (meat, fish, fresh vegetables and fruits) rich in micronutrients, and reduces access to highly specialized medical care.

Physical development of children. An objective assessment of anthropometric status revealed that, based on macrosomatotype, the integrated physical development of most preschool-age children surveyed met the criteria for «average physical development». However, a detailed component analysis revealed significant partial deviations.

In the 1–3 year age group (Table 3), both boys and girls living in radioecological control zones III and IV had significantly lower chest circumference (CC) values than the reference values and the urban Control group ($p<0.05$) during both observational seasons. This indicates persistent somatic imbalance, likely related to the negative impact of socioeconomic factors against a background of normal linear growth rates.

A similar trend was observed in children aged 4–6 years (Table 4). In boys from the RCT, CC was below average during the summer-fall period, also indicating disharmonious development. In children living in Kyiv, all indicators corresponded to the average physical development group and were harmonious.

It was established that the integrated physical development indicators for most children in both groups corresponded to average age norms. However, children permanently residing in the RCTs demonstrated a statistically significant ($p<0.05$) imbalance in physical status, manifested by a significant decrease in CC compared to their Kyiv peers. An analysis of sociodemographic factors revealed that rural families in the RCTs had a 2.3 times lower average monthly income ($p<0.05$), and mothers predominantly had secondary or specialized secondary education.

The identified imbalance in physical development in children from the RCT, manifested by a decrease in CC, may be associated with a combination of unfavorable factors. These include:

– Malnutrition: Low income among families in the RCTs can limit access to high-quality and varied foods, leading to a deficiency of nutrients necessary for the normal development of the musculoskeletal system;

– Iodine deficiency: Areas in the Ivankov district suffer from iodine deficiency, which can cause thyroid dysfunction and general metabolic problems, affecting physical development. [1,8];

– Limitations in physical activity: Socioeconomic conditions in the RCTs may create fewer opportunities for physical activity, which is important for chest development.

CC development serves as an important marker for the development of the musculoskeletal and respiratory systems. Its selective delay in the pediatric population from the RCTs likely has a multifactorial basis, with three pathogenetic mechanisms playing a leading role:

Chronic nutritional deficiencies: Financial constraints in most rural families lead to an unbalanced diet for preschool-aged children, with a deficiency of complete animal proteins, calcium, phosphorus, and vitamin D, which directly slows down the ossification and development of the chest wall. The low income of families in the RCTs can limit access to high-quality and varied foods, leading to deficiencies in nutrients necessary for the normal development of the musculoskeletal system.

Impact of endemic iodine deficiency: The Ivankiv district traditionally belongs to biogeochemical provinces with pronounced natural iodine deficiency. The resulting subclinical thyroid hormone deficiency can suppress plastic metabolism and the overall rate of metabolic processes in bone and muscle tissue.

Environmental and social restrictions on physical activity: The specific living conditions in rural areas within radioecological monitoring zones are often associated with a lack of well-equipped playgrounds and limited organized forms of physical education, which hinders chest expansion and respiratory muscle development.

Comparison with the results of other studies shows that anthropometric deviations in children from environmentally disadvantaged regions often correlate with socioeconomic status [2,3,5]. This confirms that social factors may play an even greater role than environmental factors in shaping the health of children [6,7].

Conclusions

The overall growth and weight gain rates of most preschool-aged children from radioactively contaminated and iodine-deficient regions correspond to the average statistical age indicators.

In the pediatric population living in conditions of combined radioecological contamination and iodine deficiency, a partial imbalance in physical development is observed, manifested by a statistically significant ($p<0.05$) decrease in CC compared to the Control group.

This somatotypic disharmony is closely linked to a complex of unfavorable sociodemographic factors, among which low family income (2.3 times lower than in the city) and limited maternal education are prominent.

These findings support the development of interdisciplinary regional programs aimed at improving the socio-nutritional status of children in environmental risk zones.

The authors declare no conflicts of interest.

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