METHODS FOR ASSESSING ANTHROPOMETRIC CHARACTERISTICS OF CHILDREN'S PHYSICAL DEVELOPMENT IN RELATION TO DIETARY PATTERNS

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Abstract. *In recent years, scientific research conducted in the Republic of Uzbekistan within the fields of pediatrics, neonatology, and hygiene has increasingly focused on identifying regional characteristics of children's physical development. However, the issue of differences in anthropometric indicators among children who are breastfed, mixed-fed, and artificially fed has not been sufficiently explored.*

Therefore, in order to address this scientific gap, it is essential to analyze and highlight findings aimed at identifying the specific characteristics and indicators typical of children growing under different feeding conditions (breastfeeding, mixed feeding, and artificial feeding).

The distinctiveness of this study lies in its integrated approach, combining anthropometric, statistical, and morphofunctional analyses of child development. Such an approach enables the practical application of the obtained results in medicine, particularly in pediatrics, neonatology, and pediatric nutrition science. In this context, the selection of appropriate research methods, as well as the reliability and ease of application of the obtained indicators, are considered critically important.

Keywords: *nutrition, saliva, crystallogram.*

Aim of the Study. The aim of this study is to conduct a comparative evaluation of changes in anthropometric indicators of children's physical development, as well as to analyze the advantages of modern, invasive, and experimental research methods in selecting effective approaches for determining qualitative indicators.

Results Obtained

Objective examination. Within the framework of the study, standard methods for examining children were applied: general examination, bimanual examination, and external inspection. During the general examination, body constitution, as well as the condition of the skin, hair, and nails, the degree of hair distribution, and the characteristics of adipose tissue distribution were assessed.

During the research, all necessary conditions for data collection were maintained: absence of preliminary selection of participants, consideration of children's age, and the use of the same instruments throughout the survey process.

The characteristics of physical development in children with different types of feeding attracted particular interest. To address this objective, body weight and length were measured, as well as chest circumference and head circumference. The examination was conducted in the first half of the day under comfortable conditions, with children undressed, at a room temperature of 24–26°C, strictly following all anthropometric measurement standards and using carefully calibrated instruments. Anthropometric data were evaluated using methods appropriate for each age and sex group.

All included subjects were divided into three groups:

- Group of children exclusively breastfed up to 5 months of age
- Group of children fed with artificial formulas from the first days of life
- Group of children receiving mixed feeding from the first days of life

The main objective of the study was to analyze the relationship between feeding type from the earliest days of life and anthropometric indicators of children's physical development, including body height, weight, head circumference, chest circumference, and the timing of eruption of primary teeth.

Anthropometric assessment included the following:

- assessment of physical development according to age norms;

- presence of somatic diseases;
- evaluation of nutrition and complementary feeding;
- family conditions;
- collection of life anamnesis.

This approach made it possible to identify potential influencing factors in advance. The evaluation of subjective indicators allowed for the assessment of children's physical development, as well as the determination of the intensity and frequency of morbidity.

Anthropometric examinations.

The condition of the children was studied in detail, including:

Birth weight, body length, head and chest circumference, as well as analysis of children's age-related development according to WHO standards;

Body weight was measured using electronic scales, with children placed either in a lying or standing position depending on their age. Whenever possible, children were examined wearing light clothing during measurements. Body length/height was measured using horizontal and vertical stadiometers.

Measurement of length or height. Depending on the child's age and ability to stand, either body length or height was measured. Body length was measured in the supine position, while height was measured in the standing position. If the child was younger than 2 years, body length was measured in a lying position. If the child was 2 years or older and able to stand independently, height was measured in a standing position.

The height measured in the standing position is on average 0.7 cm less than the length measured in the lying position. This difference is taken into account in WHO growth standards and corresponding growth curves. Therefore, when necessary, measurements should be adjusted accordingly:

If a child under 2 years of age cannot be measured in a lying position, height may be measured in a standing position and 0.7 cm should be added to convert it to length. If a child aged 2 years or older cannot stand, body length may be measured in a lying position and 0.7 cm should be subtracted to convert it to height.

Measurement equipment. The measuring board (stadiometer/length board) should be made of high-quality, smooth, water-resistant, lacquered or polished material. The horizontal and vertical components must be firmly fixed at a right angle. The movable part is used to support the feet when measuring length or the head when measuring height.

Head and chest circumference were measured using a measuring tape. Head circumference in children was determined by placing the measuring tape firmly around the head, passing posteriorly over the most prominent part of the occipital bone and anteriorly above the supraorbital ridge. In newborns, head circumference is typically around 34–36 cm.

Chest circumference was measured with the child in a calm state, with arms lowered and breathing normally. The measuring tape was positioned posteriorly under the lower angles of the scapulae and anteriorly across the nipples. In girls with developed mammary glands, the tape was placed anteriorly at the level of the upper edge of the fourth rib.

Materials and equipment:

- measuring tape
- 70% ethyl alcohol, gauze wipes
- pen, paper

Procedure algorithm:

- The purpose and procedure of the examination were explained to the mother
- Hands were washed and gloves were worn
- The measuring tape was disinfected with an alcohol wipe
- The child was placed in a sitting or lying position

Children's height was measured using a stadiometer in either a horizontal (lying) or vertical (standing) position, depending on age.

Body weight was measured using electronic scales, with the child positioned either standing or lying according to age.

Head circumference was measured using a measuring tape placed around the head, passing from the occipital prominence posteriorly, above the ears laterally, and across the supraorbital region anteriorly.

Chest circumference was measured using a tape in both horizontal and vertical positions depending on the child's age. The reference points for the tape were: posteriorly – the lower angles of the scapulae, and anteriorly – at the level of the fourth rib at its junction with the sternum, above the mammary glands.

The obtained anthropometric data were compared using the ANTHRO software and UNICEF reference indicators. The ANTHRO software (version 3.2.2, 2012), used for pediatric anthropometric calculations, is widely applied worldwide[37,38].

In this study, the reference population was defined according to WHO growth standards. Each of the three indicators of a child's nutritional status can be expressed in standard deviation units (Z-scores) relative to the median of the reference population.

Weight-for-age is an indicator used to assess both acute and chronic malnutrition. Children are considered moderately or severely underweight if their weight-for-age falls more than two standard deviations below the median of the reference population. Children whose weight-for-age is more than three standard deviations below the reference median are classified as severely underweight.

Height-for-age is a measure of linear growth. Children are classified as moderately or severely stunted if their height-for-age is more than two standard deviations below the median of the reference population. Those whose height-for-age is more than three standard deviations below the reference median are considered severely stunted.

Weight-for-height is used to assess wasting and overweight. Children are classified as moderately or severely wasted if their weight-for-height is more than two standard deviations below the median of the reference population. If weight-for-height falls more than three standard deviations below the reference median, the condition is classified as severe wasting (hypotrophy). The hypotrophic form of dystrophy is typically associated with inadequate nutrition. This indicator is sensitive to seasonal variations, reflecting changes in food availability or the prevalence of disease.

Assessment of neuropsychological development (NPD) was carried out using the method proposed by G.V. Pantyukhina, K.L. Pechora, and E.L. Frucht (1996), which provides a qualitative evaluation of child development and categorization into age-specific neuropsychological development groups. During the first year of life, the following developmental stages were assessed: [33,34].

1.5–3 to 5–6 months – development of visual and auditory orientation responses, cooing, and hand movements;

5–6 to 9–10 months – development of gross motor skills, preparatory stages of passive and active speech, and object-related actions;

9–10 to 12 months – development of gross motor activity, speech comprehension and production, and interactions with objects.

Based on the above method, the questionnaires developed by us made it possible to assess the age at which children acquire the following skills: visual orientation reactions, auditory orientation responses, emotional responses, gross motor activity, hand movements and object manipulation, procedural skills, play and interaction with objects, speech comprehension, and active speech. For each child, the age at which each skill emerged was recorded. A comparative analysis of the obtained data was carried out against standard reference values used in this methodology. When determining the developmental group, deficits in any indicator within a particular developmental domain were taken into account.

To evaluate the effect of feeding type on morbidity during the first year of life, parental questionnaires were conducted, and medical records reflecting the child's development and hospital

history were analyzed. In addition, each child included in the study underwent individual assessment within the framework of our research.

In modern medicine, scientific research aimed at the early detection of diseases and the development of effective diagnostic methods is becoming increasingly relevant [38]. In particular, the advancement of non-invasive yet highly accurate diagnostic approaches remains a priority in all periods. Among these, the analysis of biological fluids—especially saliva—has gained considerable attention as a means of early disease detection, and numerous large-scale studies have been conducted in this field [39,40]. The present study is also carried out within this framework, focusing on the processes of dehydration and crystallization of biological fluids (primarily saliva, and, where necessary, blood and other samples).

One of the key aspects of the study is the establishment of a standardized system for sample collection and storage. The processes of obtaining, transporting, and preparing biological fluids for initial analysis were organized in strict accordance with international standards and hygiene requirements, ensuring the accuracy, reliability, and reproducibility of the results. Therefore, in this study, not only standardized procedures for sample collection were implemented, but also uniform storage conditions were maintained, taking into account the medical status of participants and adhering to strict hygiene protocols [41].

The crystallization properties of saliva are closely associated with metabolic processes, water–electrolyte balance, and the concentration of bioactive substances in the body. In infants and young children, the type of feeding has a direct influence on saliva composition, which is subsequently reflected in the morphological characteristics of crystal structures formed during dehydration [42].

Collection and storage of saliva samples. Saliva samples were collected from infants aged 6–36 months, with careful consideration given to their physiological characteristics, age-specific developmental stage, feeding regimen, and care conditions. Due to the limited voluntary motor control typical of this age group, direct contact and passive collection techniques were used for saliva sampling [43]. All procedures were carried out with written informed consent obtained from the parents of each infant. Prior to sample collection, caregivers (mothers or guardians) were informed about the hygienic requirements and scientific purpose of the procedure. Since saliva composition may vary significantly after feeding, sample collection was recommended at least 60 minutes after feeding [40,41].

For saliva collection, only sterile, single-use devices—saliva collection swabs—were used. These swabs are designed to be soft, non-fragile, and safe for use in infants, preventing accidental chewing or swallowing. Each swab and container was prepared in advance, labeled with unique identification codes, and sealed immediately after sample collection. Saliva collection was performed while the infant was calm and alert [36]. With the assistance of a caregiver, a soft sterile swab was gently placed in the infant's mouth, specifically in the lower jaw or cheek area, for approximately 2–3 minutes. During this time, the infant was soothed using visual and auditory interaction, allowing the swab to absorb saliva naturally through light chewing movements. A sufficient volume of saliva (at least 0.5–1 ml) was collected. After collection, each sample tube was labeled with an individual code or number to ensure confidentiality of personal data [38,39].

Additionally, specific data were recorded for each sample, including date of birth (age in months), sex, health status (based on medical records), type of feeding (breastfeeding, artificial, or mixed), and study group (control or main group).

Microscopic analysis. The digital microscope used in this study (see Figure 2.1) is a multifunctional device developed through the integration of modern technologies, including optical microscopy, an advanced photoelectric conversion system, and LCD display technology. Unlike traditional binocular optical observation, this microscope allows direct visualization of the microscopic field on a screen, significantly improving the efficiency of the observation process [39].

The microscope is equipped with a high-resolution 14-megapixel camera and utilizes a CMOS color image sensor capable of capturing images in HD quality. The device can be connected to a

computer via a USB 2.0 interface, enabling real-time image display at a speed of up to 480 Mb/s. This microscope is suitable for prolonged observation and detailed analysis [42,43].

Among compact microscope types, digital microscopes are particularly widespread, as their primary function is not only to magnify the observed object but also to provide high-quality image and video acquisition for scientific research purposes [52].

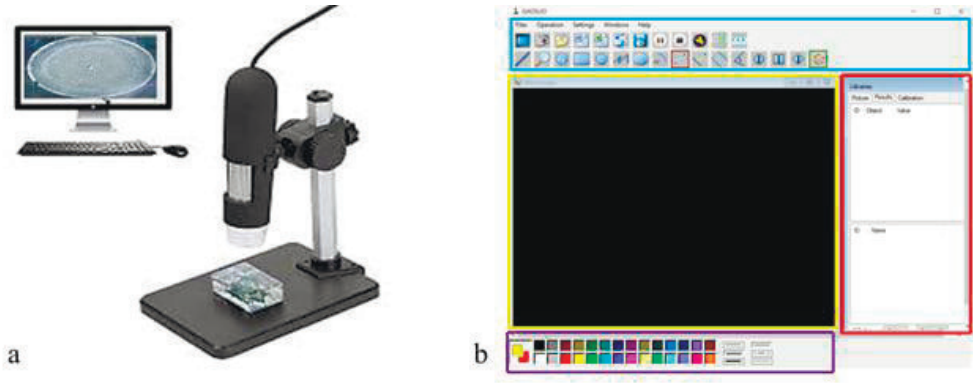


Figure 1. Figure 1a – digital microscope; Figure 1b – GAOSUO software interface: tools and settings window for working with digital microscope images

The digital microscope used in this study was placed inside a specially isolated chamber, which ensured the stability of the internal environment during the experiment. This design minimizes the influence of external factors such as temperature fluctuations, airflow, and humidity changes on the experimental process. As a result, optimal and stable conditions were created for observations carried out using the microscope. Inside the device, the temperature was maintained at 25 °C, while relative humidity was kept at approximately 32%. This made it possible to observe subtle physical changes occurring at the microscopic level without interference from external environmental factors [42]. The use of an isolated system ensures the reproducibility, reliability, and objectivity of the experiment.

Dehydration method. During the evaporation process, the selected substrate material significantly affects the characteristics of droplet dehydration. Studies indicate that surface properties, moisture resistance, and chemical inertness are key factors determining substrate performance. The glass surface used in this study is smooth, flat, and chemically inert, meaning it does not react with the saliva sample and does not interfere with evaporation or crystallization processes [42,43].

During sample preparation, the liquid was carefully applied onto the prepared glass substrate using a special dispenser (micropipette) (see Figure 2).



Figure 2. Droplet detachment and deposition onto the surface

The applied saliva droplet (typically around 50 μL) assumes its shape on the glass surface under the influence of natural forces—surface tension and adhesion—and spreads according to the open droplet model. Observations based on this model demonstrate that the evaporation rate differs significantly between the central region and the peripheral zones of the droplet. Evaporation occurs more rapidly at the periphery, which, under the influence of internal convective flows and surface forces, leads to the outward movement of molecules and ions from the center toward the edges [43].

Statistical analysis of research results

Statistical analysis was carried out using MS Office Excel 2007 and the STATISTICA for Windows 10 software package, in accordance with standard statistical methods. The level of significance was set at $p<0.05$. For normally distributed data, Student's t-test was applied to assess differences and to analyze dynamic changes both within groups and across the population. Correlation analysis was performed using Pearson's coefficient for normally distributed data and Spearman's coefficient for non-normal distributions.

Results were presented as M±m. For visualization of the results and primary morphological data, Microsoft Office charting tools and the graphical capabilities of STATISTICA for Windows were widely utilized. The significance level was set at $p<0.05$. Based on the results of all applied statistical criteria, clear conclusions were drawn regarding the presence or absence of statistically significant differences.

The obtained data were processed statistically using a Pentium-IV personal computer with Microsoft Office Excel 2010. Both parametric and non-parametric statistical methods were applied, including calculation of the mean (M), standard deviation (σ), standard error (m), and relative values (frequency, %). When comparing mean values, statistical significance was determined using the Student's t-test, taking into account variance analysis (Fisher's F-test) and distribution characteristics (including excess/kurtosis). The probability of error (R) was also considered. Quantitative data were analyzed to determine mean values and standard errors, with significance levels set at $R<0.05$ and $R<0.001$. For qualitative variables, statistical significance was assessed using the χ^2 (chi-square) test and the z-test.

Conclusion. The present study provides a multidimensional assessment of children's physical development by integrating classical anthropometric techniques with statistical analysis and morphofunctional diagnostics. The findings underscore that the type of feeding in early life constitutes a significant, yet not isolated, determinant of growth trajectories, influencing key indicators such as body weight, linear growth, and proportional development. However, the observed variations should be interpreted within a broader biopsychosocial context, as factors such as environmental conditions, genetic predisposition, and quality of complementary feeding may act as confounding variables.

A notable strength of the study lies in its methodological rigor, including adherence to WHO growth standards and the application of standardized measurement protocols, which enhances the validity and comparability of the results. At the same time, certain methodological limitations should be acknowledged. The cross-sectional nature of the analysis restricts the ability to establish causal relationships between feeding type and developmental outcomes. In addition, while the incorporation of saliva crystallization analysis represents an innovative and minimally invasive diagnostic approach, its clinical applicability and sensitivity require further validation through longitudinal and larger-scale studies.

The integration of anthropometric monitoring with emerging biofluid-based diagnostic methods demonstrates considerable potential for improving early detection of developmental deviations. Nevertheless, future research should prioritize longitudinal designs, expanded sample sizes, and the inclusion of additional biological and socioeconomic variables to strengthen the evidence base and ensure the generalizability of findings.

In conclusion, while the study contributes valuable insights into the relationship between feeding practices and child development, it also highlights the necessity for more comprehensive and methodologically robust investigations. The advancement of integrated diagnostic frameworks holds promise for enhancing pediatric monitoring systems, yet their practical implementation must be supported by further empirical validation and critical evaluation.

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