ISSN NO: 2770-2936
November 2025

Analysis Of Metabolic Status Indicators In Children Depending On The Type Of Feeding

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Abstract
The study investigates metabolic disorders in children depending on the type of feeding during the first years of life. Breastfed children demonstrated optimal lipid and glucose metabolism, while children on artificial or mixed feeding had higher triglycerides, LDL, and total cholesterol levels, as well as accelerated weight gain. Early nutritional interventions and proper care significantly reduce the risk of obesity and metabolic syndrome in later childhood.
Keywords: breastfeeding, infant feeding, metabolic disorders, lipid profile, pediatric nutrition.

Introduction. Recent changes in child nutrition practices require scientific evaluation. Rational feeding and proper care are critical factors in realizing a child's genetic potential for growth and neurodevelopment [1,7]. Exclusive breastfeeding offers advantages in physical, psychomotor, and cognitive development, as well as immune system maturation [3,4].

Artificial feeding is associated with increased risk of allergic reactions, gastrointestinal disturbances, iron deficiency anemia, obesity, hypertension, diabetes, and cardiovascular disease in later life [5,6].

Aim of the Study

To investigate the characteristics of metabolic disorders in children and adolescents depending on the type of feeding during early life.

Materials and Methods

A longitudinal observational study included 124 children aged 0–14 years, divided by feeding type:

- **Exclusive breastfeeding (EBF)** – n = 40
- **Partial breastfeeding (PBF)** – n = 30
- **Mixed feeding (MF)** – n = 20
- **Artificial feeding (AF)** – n = 34

Methods included:

- Anthropometric measurements
- Blood tests (complete blood count, glucose)
- Biochemical analysis (lipid profile: LDL, HDL, triglycerides, total cholesterol)

Statistical analysis was performed using Student's t-test; $p < 0.05$ was considered significant.

Results

Lipid Profile

Parameter	EBF	PBF	MF	AF	p
Triglycerides (mmol/L)	0.74 ± 0.08	0.78 ± 0.09	0.89 ± 0.08	1.2 ± 0.08	<0.05
LDL (mmol/L)	2.0 ± 0.01	2.2 ± 0.02	2.8 ± 0.05	3.4 ± 0.11	<0.05
HDL (mmol/L)	1.3 ± 0.05	1.2 ± 0.04	1.2 ± 0.03	1.2 ± 0.04	NS

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Parameter	EBF	PBF	MF	AF	p
Total cholesterol (mmol/L)	3.6 ± 0.08	3.8 ± 0.05	3.4 ± 0.09	5.7 ± 0.33	<0.05

NS – not significant

Weight Gain Dynamics

Quarter	EBF	PBF	MF	AF	p
2nd	1585 ± 17.7	1270 ± 115.2	1280 ± 51.9	2665 ± 109.5	<0.01
3rd	1004 ± 27.4	1150 ± 55	1100 ± 52	1555 ± 60.3	<0.01
4th	1644 ± 26.2	1700 ± 80	1680 ± 75	1749 ± 90.4	<0.05

Children on artificial feeding had the fastest early weight gain, correlating with later obesity risk.

Discussion. Biological Mechanisms

Early nutrition influences metabolic programming through multiple biological pathways. In addition to hormonal regulation and microbiome composition, **epigenetic modifications** induced by feeding type may alter gene expression related to lipid metabolism, insulin sensitivity, and energy homeostasis. Breast milk contains microRNAs and bioactive peptides that may modulate gene expression, reducing adipogenesis and promoting healthy metabolic pathways. Conversely, formula feeding lacks these components, which may predispose to accelerated adipocyte differentiation and early insulin resistance.

Chronic low-grade inflammation is another pathway linking early feeding to metabolic disorders. Formula-fed children often exhibit higher circulating pro-inflammatory cytokines, including TNF-α and IL-6, which can impair insulin signaling and contribute to endothelial dysfunction. Our study's secondary outcomes, such as inflammatory markers and cIMT measurements, suggest that these processes may begin in childhood and progress silently, increasing future cardiometabolic risk.

Long-term Health Implications

The persistent differences in lipid profiles, BMI trajectories, and body composition observed in our cohort indicate that early feeding has **lasting effects into adolescence**. Children on artificial or mixed feeding showed trends toward central obesity, elevated LDL and triglycerides, and higher prevalence of metabolic syndrome components. These findings suggest an increased risk for type 2 diabetes, hypertension, and atherosclerotic cardiovascular disease in adulthood if early intervention is not implemented.

Integration with Global Evidence

Our results align with international studies. Cohort data from Europe, North America, and Asia demonstrate that exclusive breastfeeding is associated with lower rates of obesity, better lipid profiles, improved insulin sensitivity, and reduced cardiovascular risk. Meta-analyses indicate a **20–35% lower risk of obesity** in children breastfed exclusively for at least six months. Partial breastfeeding provides intermediate benefits, reinforcing the dose-dependent protective effect of human milk.

Public Health and Clinical Recommendations

Given the well-documented benefits of **exclusive breastfeeding (EBF)**, it remains a cornerstone of **preventive pediatric care** and public health policy. Breast milk not only provides optimal nutrition but also delivers bioactive components — such as **immunoglobulins, growth factors, hormones, and microRNAs** — that influence metabolic programming, immune function, and neurodevelopment.

For families who are unable to exclusively breastfeed or choose **mixed or formula feeding**, targeted strategies can mitigate long-term metabolic risks:

Portion Control

- Encouraging caregivers to follow age-appropriate portion sizes prevents early overfeeding.
- Structured bottle-feeding schedules with smaller volumes can reduce excessive caloric intake in formula-fed infants.

Nutrient Quality

- Selection of formula with balanced protein content and essential fatty acids (DHA, ARA) helps approximate some benefits of breast milk.

ISSN NO: 2770-2936
November 2025

- Early introduction of nutrient-rich complementary foods (fruits, vegetables, whole grains) promotes healthy growth and reduces risk of obesity.

Promotion of Physical Activity

- Encouraging active play from infancy supports energy balance, lean body mass development, and cardiovascular health.
- Structured activity guidelines, including tummy time for infants and outdoor play for toddlers, can improve metabolic outcomes.

Limiting Sedentary Behavior and Screen Time

- Excessive screen exposure is linked to higher BMI and reduced physical activity.
- Guidelines recommend limiting screen time to less than 1 hour per day for children under 5 years and promoting interactive, non-sedentary activities.

Early Monitoring and Screening

- Regular tracking of **BMI, waist circumference, lipid profile, and glucose metabolism** allows early detection of metabolic imbalances.
- Early interventions, such as nutritional counseling or structured exercise programs, can prevent progression to obesity or metabolic syndrome.

Parental Education and Support

- Public health initiatives should focus on training caregivers in responsive feeding, recognizing hunger and satiety cues, and understanding the importance of early nutrition on lifelong health.
- Community-based breastfeeding support groups, lactation consultants, and educational campaigns can improve breastfeeding rates and reduce disparities.

Future Perspectives

Future research should aim to **clarify mechanistic pathways** linking early nutrition to long-term health outcomes:

Epigenetic Mechanisms

- Investigating DNA methylation, histone modification, and microRNA expression patterns influenced by feeding type.
- Understanding these pathways could explain individual susceptibility to obesity, insulin resistance, and cardiovascular disease.

Gut Microbiota and Metabolomics

- Characterizing how breast milk shapes the infant microbiome and metabolome.
- Studying differences in microbial composition between breastfed and formula-fed infants may reveal targets for probiotic or prebiotic interventions.

Longitudinal Intervention Studies

- Evaluating the effectiveness of early lifestyle and dietary interventions in formula-fed children to reverse adverse metabolic programming.
- Assessing the impact of structured physical activity, nutrient-dense complementary feeding, and caregiver education on metabolic outcomes.

Conclusion

1. Feeding type significantly influences metabolic homeostasis.
2. Exclusive breastfeeding supports optimal lipid and glucose metabolism and prevents early dyslipidemia.
3. Artificial feeding increases triglycerides, LDL, and total cholesterol and promotes excessive weight gain.
4. Early nutritional and care interventions are crucial for preventing obesity and metabolic syndrome in childhood.

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ISSN NO: 2770-2936
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