

Physical and psychomotor development of preterm infants using Munich Functional Developmental Diagnostics: a cross-sectional study comparing feeding methods in first year

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Abstract

Introduction: Newborns born prematurely due to the loss of optimal developmental conditions provided by the mother's body are at risk of impaired physical and psychomotor development. In order to optimize external conditions, we are searching for an optimal feeding method for this group of children.

Aim of the research: This study investigated the impact of feeding methods on the physical and psychomotor development of 210 moderate to late preterm infants (32–36 6/7 weeks of gestation) at 12 months of age, and their ability to match full-term newborns' development.

Material and methods: Infants were divided into two groups based on the feeding method: breastfeeding ($n = 91$) and formula feeding ($n = 119$). Measures included obstetric and neonatal risk factors, MFDD (Munich Functional Developmental Diagnostics) scores, and anthropometric data. Comparative analysis was conducted using a full-term infant database.

Results and conclusions: Among children born prematurely (32–36 6/7 weeks of gestation), during the neurological examination at 12 months of age, there was no statistically significant difference in the individual axes of the MFDD scale between breastfeeding and formula-feeding children. There were also no differences in physical development between the groups. Children born in 32–36 6/7 weeks of gestation show no differences in psychomotor development measured on the MFDD scale or differences in weight gain and head circumference at 12 months of age compared to full-term newborns.

Introduction

Preterm new-borns are at risk of impaired physical and psychomotor development due to the loss of optimal developmental conditions, which are supplied by the mother's body [1]. In addition to genetic predispositions, the developmental process also depends on the broadly understood environment affecting the child's immature body. The development of medicine constantly strives to optimize the external conditions for the development of preterm infants, so that they could achieve their genetic potential despite a difficult start and so that they do not deviate from their peers. One of the aims of the study is to find the optimal way of feeding children. Breast milk is the recommended nutrition for preterm infants as it provides the most important nutrients as well as some biologically active components which support optimal physical and neurological development, immune functions and a healthy microbiome of the body [2, 3]. In addition, it has a proven protective effect against one of the severe complications of prematurity: necrotising enterocolitis (NEC) [4, 5].

It is important to remember that preterm infants, due to their immaturity, may encounter difficulties with feeding and signalling hunger, and, compared to full-term newborns, they also have a much higher demand for some nutrients. Modified milk provided at fixed times and quantities allows for a precise control of the portions consumed by the child. This aspect is more difficult to assess during breastfeeding. Therefore, the question arises whether the method of feeding has a significant impact on the physical and psychomotor development of children.

Aim of the research

The aim of our study was to assess the physical and psychomotor development of preterm babies (32–36 6/7 weeks of gestation) at 12 months of corrected age, depending on the method of feeding (breastfeeding vs. formula feeding). The moderate and late preterm group accounts for approximately 84% of all preterm newborns [6]. Anthropometric measurements after birth and (at 12 months of corrected age) were applied to Fenton growth charts [7]. The psychomotor devel-

opment was assessed at 12 months of corrected age using the Munich Functional Developmental Diagnostics (MFDD), which enables early diagnosis of eight key psychomotor functions in infancy.

Additionally, utilizing the current database and the database from our previous analogous analysis regarding full-term infants [8], we have decided to investigate whether moderate and late preterm infants, when fed using the same method as full-term infants, achieve similar results in psychomotor and physical development. We wanted to determine if moderate and late preterm infants can catch up with full-term newborns in both physical and psychomotor development in both the breastfed group and the formula-fed group.

Material and methods

The study had a cross-sectional character, and was conducted and described in accordance with the STROBE methodology [9]. All the infants born at the Obstetrics and Gynaecology Clinic of the Provincial Combined Hospital in Kielce between January 2016 and December 2018 at a foetal age of 32–36 6/7 weeks of gestation were invited to participate in the study. The infants whose parents responded positively to the written invitations sent to them were included in the study. The preterm infants born in a severe condition (0–3 points, Apgar scale), infants with congenital defects and infants who presented symptoms of an illness (infectious or otherwise) during the study were excluded. The children were examined in (at 12 months of corrected age) by a child neurologist who had obtained a certificate proving the capability of making assessments on the MFDD scale and had already had 2 years of experience. Prior to the start of the study, the legal guardian signed informed consent for the child to participate in the study and completed a survey including the information about the child, such as the manner of feeding the infant from birth until 12 months of corrected age. During the study, the child had to be well-rested, full and without any signs of infection. The examination took place in a specially prepared room, in the presence of one related adult known to the child.

The children included in the study were divided into two groups. Group 1 (breastfeeding) included all the children who had been fed only with human milk until at least 6 months of age or longer. Children over 6 months of age had complementary food introduced in accordance with currently applicable recommendations [10–12]. Infants weighing < 2000 g or with intrauterine growth restriction received breast milk along with human milk fortifier (HMF) during the neonatal period, in accordance with current recommendations [13].

In the second group (formula feeding), we qualified children who did not meet the criteria of group 1 and were fed only with formula milk or in a mixed

manner and had had complementary foods introduced after the age of 6 months.

MFDD allows for an early diagnosis of the eight most important psychomotor functions in infancy, i.e., crawling [MFDD 1 axis], sitting [MFDD 2 axis], walking [MFDD 3 axis], grasping [MFDD 4 axis], perception [MFDD 5 axis], speaking [MFDD 6 axis], speech comprehension [MFDD 7 axis] and social skills [MFDD 8 axis]. MFDD is a tool based on standardised tables of physical development according to Hellbrügge and Pechstein [14], containing a standard pattern for a given function in each month of life. The design of the method is based on the premise that each month of life should be assigned the behaviour which is displayed by 90% of children examined at that age. The method is therefore based on the concept of “minimum behaviour”, i.e., behaviour that was presented by 90% of the children tested in the relevant month of life, rather than an average value or average behaviour. This categorisation of the typical behavioural patterns of a specific calendar age is used primarily to detect developmental delays or deficits [15].

When assessing psychomotor development with the MFDD, we created an assessment sheet of the child’s developmental condition. Using categorical scale assessments, we indicated whether the child had achieved the typical pattern of behaviour for a particular month of life. In most tasks, behaviour patterns were separated from one another by 1 month. If a child had not achieved typical behavioural patterns until a specific month, the data was coded as total negative values, corresponding to the number of months by which a delay in the development of a specific function occurred in a child [16]. During the analysis of the child’s developmental profile, which is a combination of the result of 8 assessed psychomotor functions, we paid attention to negative deviations (below the corrected age). A deviation of 2 months is indicative of pathology, while a deviation of 1 month may be within the developmental norm [16].

The sample size was calculated to detect a minimum difference between groups of at least 0.1 points on one of the scale axes, with the power of 90% and the a level of 5%. We obtained a preliminary prevalence of differences from an earlier study [15]. We presented the qualitative variables using the percentage share per given group, and we compared the groups using Pearson’s χ^2 test. We also presented the percentage of children in whom a deviation developed in at least one axis included in one of the dimensions extracted earlier in the principal component analysis as qualitative variables [15]. We presented the central tendency of the quantitative variables using the mean value, and we used the standard deviation as a measure of dispersion. If a child did not adopt the kind of behaviour typical of a given age, we coded the data as a negative number, corresponding to the number

of months by which the child shows a delay in the development of a particular function. The analysis was conducted using Statistica 13.1 software (Tibco Software Inc., Palo Alto). We considered a difference to be statistically significant when $p < 0.05$.

After conducting the analysis, we decided to compare the psychomotor outcomes and physical measurements of moderate and late preterm infants (32–36 6/7 weeks of gestation) with full-term newborns (≥ 37 weeks of gestation) in different feeding methods. For this purpose, we utilized the previously developed database of full-term infants, which was also used in our previous publication [8]. We compared the psychomotor outcomes assessed using the MFDD scale, as well as physical measurements (weight gain and head circumference at 12 months of age) in the group of breast-feeding infants, comparing moderate and late preterm infants versus full-term infants. We also compared the same outcomes in the group of formula feeding infants, comparing moderate and late preterm infants versus full-term infants. The Mann-Whitney U test was used for the analysis.

Results

Approximately 500 moderate and late preterm infants were invited to take part in the study by means of a written invitation. A positive initial response was obtained from 250 children. 210 children born at the Obstetrics and Gynaecology Clinic of the Provincial Combined Hospital in Kielce, from January 2016 to December 2018, at a gestational age of 32–36 6/7 weeks of gestation weeks of gestation, were included in the study.

Group 1 (breast-feeding) consisted of 91 children, of whom 5 were fed mother's milk until the age of 6 months, 13 children – until the age of 9 months, and 73 – until the age of 12 months. This means that 43% of all premature infants participating in the study were fed in accordance with the current recommendations: only with mother's milk until the end of the 6th month or longer, of which 5.5% only until the end of the 6th month, 14.3% until the end of the 9th month of life and as much as 80.2% until the time of the study, i.e., the 12th month of life.

Group 2 (formula feeding) consisted of 119 children, most of whom were fed with formula milk right after birth or in the first quarter of their life (81.5%). Only 31 children (18.5%) were given formula milk in the second quarter of their life and further feeding included only formula milk.

Selected demographic parameters from the period of pregnancy, childbirth, and the postpartum period within the separated groups (breastfeeding vs. formula feeding) were analysed. The results of the analysis were presented in Table 1.

There was a significant difference in the occurrence of gestational hypertension (12.09% in the

group of the breastfed children vs. 26.05% in the group of formula-fed children ($p = 0.012$)) and in the mother's education (in the first group, 81.11% of mothers had higher education, while in the second group, 62.18% of mothers had such education ($p = 0.003$)). The clinical condition of the newborns, assessed according to the percentage of newborns born in the medium condition (4–7 points) in the 1st and 5th minute after birth, did not differ between the groups. No statistical differences were found in the analysis of weight gain and head circumference increase in the 12th month.

Tables 2 and 3 show a comparison of the groups on the MFDD scale. Table 2 presents the results in a qualitative form in the case of any deviation in one of the three scale dimensions. The dimensions were distinguished in the principal component analysis in a separate study [15]. Particular dimensions consisted of dimension 1 – MFDD axis 1–4, dimension 2 – MFDD axis 6–8, dimension 3 – MFDD axis 5. Table 3 (graphically presented as Figures 1 and 2) shows a comparison of the groups in terms of the mean values of deviations on each axis of the MFDD scale. The analysis of individual functions on the MFDD scale exhibited no statistically significant differences between groups in the analysis of the functions of gross and fine motor skills (MFDD 1–4), perception (MFDD 5), active speech (MFDD 6) and passive speech (MFDD 7) and at the level of social skills (MFDD 8).

The additional analysis included the examination of psychomotor outcomes assessed using the MFDD scale in breast-feeding infants (Table 4) and formula feeding infants (Table 5), based on gestational age (moderate and late preterm infants, 32–36 6/7 weeks vs. full-term infants, ≥ 37 weeks). In the group of breast-feeding infants, we compared moderate and late preterm infants (91 children) and full-term infants (146 children). In the group of formula feeding infants, we compared moderate and late preterm infants (119 children) and full-term infants (96 children). Both in the group of breast-feeding infants and formula feeding infants, no differences in psychomotor development were observed between infants born at 32–36 6/7 weeks and those born at ≥ 37 weeks. We compared birth measurements, as well as weight gain and head circumference growth at 12 months of age, between preterm and full-term infants in both the breastfed and formula-fed groups. Despite differences in birth measurements (moderate and late preterm infants had smaller birth measurements than full-term newborns) (Tables 6 and 7), no differences in weight gain and head circumference growth were observed at 12 months of age between moderate and late preterm infants and full-term infants in the breastfed group (Table 8). In the formula-fed group, no differences were observed in head circumference growth at 12 months of age between moderate and late preterm infants and full-term infants, while a difference in weight gain

Table 1. Demographic characteristics of the group

Parameter	Group 1 (breastfeeding) (n = 91)	Group 2 (formula feeding) (n = 119)	P-value
Pregnancy			
Singleton pregnancy	91.21%	69.75%	0.00015*
First pregnancy	51.65 %	62.18%	0.120
Hypertension in pregnancy	12.09%	26.05%	0.012*
Gestational diabetes mellitus	5.49%	10.92%	0.160
Hypothyroidism in pregnancy			
Magnesium sulphate administration in pregnancy	22.99%	40.18%	0.034*
Antenatal steroids	43.33%	69.75%	0.00013*
History of antenatal bleeding	7.69%	10.92%	0.420
Birth			
Male sex	65.56%	51.26%	0.039*
Caesarean section	60.00%	79.83%	0.124
< 34 Hbd/weeks of gestation	13.19%	26.89%	0.016*
Nuchal cord at birth	26.67%	17.80%	0.124
Newborn's pulmonary resuscitation	38.46%	36.13%	0.000*
Newborn's cardiopulmonary resuscitation	1.10%	3.37%	0.059
Congenital infection	18.89%	16.95%	0.720
Respiratory insufficiency	37.30%	41.18%	0.576
Transfusion in neonatal period	5%	9%	0.030*
Apgar 1' 4–7	19.78%	17.65%	0.637
Apgar 5' 4–7	7.69%	10.08%	0.540
Apgar 1' < 8	19.78%	18.49%	0.813
Apgar 5' < 8	7.69%	10.08%	0.549
Hospitalization			
Pneumothorax	0%	0.84%	0.381
TTN	6.59%	10.08%	0.371
RDS	12.09%	5.04%	0.043*
Anemia	12.09%	20.17%	0.119
Increase in 12 months			
Head circumference increase over 12 months	27.661	28.697	0.203
Weight gain over 12 months	7246.033	7169.534	0.977
Maternal variables			
Mother with higher education	81.11%	62.18%	0.003*

*Statistically significant difference.

was observed, namely full-term infants had a lower weight gain percentile (not absolute values) compared to moderate and late preterm infants (43rd percentile vs. 61st percentile, $p = 0.039$) (Table 9). This difference seems to have little clinical significance as both percentile values fall within the normal range, and there is no statistically significant difference in absolute weight gain values expressed in grams.

Discussion

The MFDD scale is used in the assessment of the development of preterm infants. During the assessment, we relied on the child's corrected age and paid attention to negative deviations, i.e., deviations downwards from the corrected age. The usefulness of the MFDD method for the assessment of motor

Table 2. Comparison of the percentage of deviations in individual scale dimensions between groups

Variable	Group 1 (breastfeeding)	Group 2 (formula feeding)	P-value
MFDD 1 st dimension $\neq 0$	27.47%	21.85%	0.346
MFDD 2 nd dimension $\neq 0$	8.79%	11.76%	0.486
MFDD 3 rd dimension $\neq 0$	2.20%	5.88%	0.191
Any deviation in scale	10.99%	15.13%	0.382

Table 3. The means of deviations on the individual axes between groups

Variable	Group 1		Group 2		P-value
	Mean	SD	Mean	SD	
MFDD 1 st dimension sum total	-0.736	1.873	-0.891	2.651	0.521
MFDD 2 nd dimension sum total	-0.176	0.754	-0.269	1.110	0.710
MFDD 3 rd dimension sum total	-0.022	0.147	-0.092	0.412	0.643
MFDD 1	-0.253	0.811	-0.218	0.815	0.702
MFDD 2	-0.055	0.311	-0.168	0.680	0.662
MFDD 3	-0.407	0.919	-0.412	0.960	0.752
MFDD 4	-0.022	0.147	-0.092	0.412	0.643
MFDD 5	-0.033	0.180	-0.109	0.517	0.741
MFDD 6	-0.099	0.335	-0.151	0.481	0.775
MFDD 7	-0.044	0.254	-0.067	0.406	0.912
MFDD 8	-0.033	0.233	-0.050	0.341	0.967
MFDD sum total	-0.198	0.763	-0.361	1.394	0.590

SD – standard deviation.

skills [17] as well as language skills in preterm infants was demonstrated [18]. The use of the MFDD scale in evaluating 8 diverse psychomotor areas allows the delay in each of the examined functions to be recognized in an accessible way. A delay of 1 month requires observation, but may still fall within the developmental norm variant, which may explain the high proportion of children with deviations in the individual dimensions of the scale (Table 2). A delay of 2 months in a specific function in the first year of life always raises suspicions of pathology and requires further diagno-

sis [19]. The MFDD scale thus makes it possible to accurately select the infants being in need of appropriate therapy due to psychomotor developmental delays and, by being used in the assessment of the progress of children with developmental disabilities, it can contribute to establishing certain developmental patterns in children with specific developmental disorders [20].

Children born prematurely are at risk of impaired psychomotor development due to the premature loss of optimal developmental conditions. To ensure

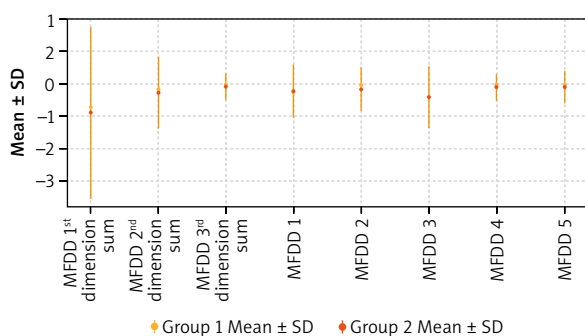
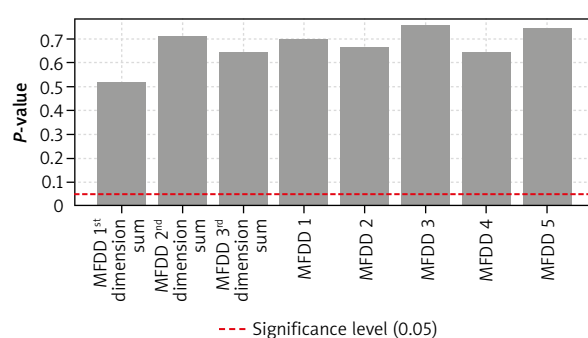
**Figure 1.** The plot shows the mean and SD values for Group 1 and Group 2 for the individual axes**Figure 2.** The plot shows the *p*-values for the comparisons between Group 1 and Group 2 for the individual axes

Table 4. Comparison of preterm vs. full-term infants in the breastfed children

Variable	Preterm		Full-term		P-value
	Mean	IQR	Mean	IQR	
MFDD 1	−0.174	2.000	−0.258	5.000	0.832
MFDD 2	−0.043	1.000	0.000	N/A	0.238
MFDD 3	−0.391	3.000	−0.250	3.000	0.253
MFDD 4	0.000	N/A	−0.029	1.000	0.431
MFDD 5	0.000	N/A	−0.059	2.000	0.431
MFDD 6	−0.174	2.000	−0.089	1.000	0.593
MFDD 7	−0.130	2.000	0.000	N/A	0.087
MFDD 8	−0.087	2.000	0.000	N/A	0.237

IQR – interquartile range.

Table 5. Comparison of preterm vs. full-term infants in the formula-fed children

Variable	Preterm		Full-term		P-value
	Mean	IQR	Mean	IQR	
MFDD 1	−0.115	3.000	−0.519	5.000	0.176
MFDD 2	−0.077	2.000	−0.185	2.000	0.341
MFDD 3	−0.385	2.000	−0.630	3.000	0.614
MFDD 4	−0.038	1.000	−0.222	1.000	0.052
MFDD 5	−0.038	1.000	−0.148	4.000	0.979
MFDD 6	−0.308	2.000	−0.370	6.000	0.502
MFDD 7	−0.115	1.000	−0.074	1.000	0.623
MFDD 8	−0.077	2.000	−0.148	2.000	0.594

IQR – interquartile range.

Table 6. Comparison of birth dimensions of preterm vs. full-term infants in the group of breastfed children

Variable	Preterm		Full-term		P-value
	Mean	IQR	Mean	IQR	
Birth weight [kg]	2673.913	2290.000	3419.412	1540.000	0.000002*
Birth weight percentile	60.826	82.000	58.706	78.000	0.591
Length [cm]	50.130	14.000	54.059	9.000	0.000019*
Length percentile	90.435	42.000	91.412	43.000	0.813
Head circumference [cm]	32.630	9.000	34.559	6.000	0.003422*
Head circumference percentile	61.000	88.000	54.676	97.000	0.388

IQR – interquartile range. *Statistically significant difference.

optimal postnatal development conditions for preterm infants, we searched for the optimal feeding method. The scientific data on the impact exerted by the feeding method on the psychomotor development of children is ambiguous. There are studies showing better psychomotor development of preterm infants fed with mother's milk compared to the artificial formula milk intended for preterm infants [21, 22].

Although slower physical development is associated with poorer neurological development, benefits were observed even in situations when breastfeeding was associated with slower physical development of the child. According to a meta-analysis involving 17 studies, breastfed children perform better in intelligence tests in childhood and adolescence [23]. The link between breast milk consumption and better neuro-

Table 7. Comparison of birth dimensions of preterm vs. full-term infants in the group of formula-fed children

Variable	Preterm		Full-term		P-value
	Mean	IQR	Mean	IQR	
Birth weight [kg]	2398.462	2130.000	3325.926	1530.000	0.000001*
Birth weight percentile	47.577	96.000	51.630	79.000	0.423
Length [cm]	49.038	10.000	53.519	8.000	0.000002*
Length percentile	85.885	79.000	88.815	53.000	0.503
Head circumference [cm]	32.308	6.000	34.111	7.000	0.000850*
Head circumference percentile	63.154	72.000	44.815	97.000	0.031*

IQR – interquartile range. *Statistically significant difference.

Table 8. Anthropometric dimensions at 12 months of age: preterm vs. full-term infants in the group of breastfed children

Variable	Preterm		Full-term		P-value
	Mean	IQR	Mean	IQR	
Birth weight [kg] at 12 months of age	9.842	6.200	9.673	3.600	0.845
Birth weight percentile at 12 months of age	60.087	99.000	56.676	90.000	0.720
Length [cm] at 12 months of age	77.043	14.500	76.265	13.000	0.457
Length percentile at 12 months of age	64.739	94.000	60.029	98.000	0.562
Head circumference [cm] at 12 months of age	44.891	50.500	46.047	7.000	0.182
Head circumference percentile at 12 months of age	70.454	95.000	59.176	99.000	0.061

IQR – interquartile range.

Table 9. Anthropometric dimensions at 12 months of age: preterm vs. full-term infants in the group of formula-fed children

Variable	Preterm		Full-term		P-value
	Mean	IQR	Mean	IQR	
Birth weight [kg] at 12 months of age	9.185	4.700	9.746	5.700	0.109
Birth weight percentile at 12 months of age	43.654	96.000	61.222	95.000	0.0397*
Length [cm] at 12 months of age	73.519	13.000	74.370	10.000	0.177
Length percentile at 12 months of age	33.308	96.000	48.593	94.000	0.076
Head circumference [cm] at 12 months of age	45.596	5.000	45.615	12.000	0.936
Head circumference percentile at 12 months of age	51.462	88.000	60.000	100.000	0.225

IQR – interquartile range. *Statistically significant difference.

logical development should be perceived in the biologically active components of breast milk contributing to brain growth [24], and in the presence of long-chain polyunsaturated fatty acids (arachidonic acid and docosahexaenoic acid), favouring the process of myelogenesis and the development of the nervous system [25]. The creation of a close bond between the mother and the breastfed child further promotes the improvement of neurological development [26].

The results of a comprehensive meta-analysis from 2022, involving almost 90,000 premature infants remain in contrast with the above data, demonstrated the advantage of breast milk versus formula milk for premature infants in improving psychomo-

tor development [27]. Another meta-analysis from 2019, in addition to the lack of impact of breastfeeding on psychomotor development, demonstrated a faster rate of physical development in formula-fed children [28]. These discrepancies in the results may stem from different patterns of feeding with mother's milk (different portions and frequency), the size of the study group or maternal comorbidities, and certainly are the basis for expanding research work on this issue. In our study, we did not observe a difference between breastfed vs. formula-fed children in motor functions (MFDD 1–4), perception (MFDD 5), active speech (MFDD 6) and passive speech (MFDD 7) and at the level of social skills (MFDD 8). An analysis

of the three uncorrelated dimensions of the MFDD scale, determined during the PCA, explaining 80.27% of the total variance [15], did not show any statistically significant differences between the groups.

Preterm infants are at risk of impaired physical development [29, 30]. Due to immaturity and frequent adaptational disorders, they require regular feeding and for their calorific requirements to be met. When breastfeeding is applied without controlling the portions eaten, there may be a risk of insufficient weight gain in a preterm infant who signals their needs poorly. The consequence of impaired physical development can be a deterioration of psychomotor development [31]. In our study, we did not observe differences in physical development depending on the method of feeding.

Separation of the mother and the newborn after childbirth, the need for mechanical stimulation of lactation by the mother and the difficulty in suckling directly from the breast due to immaturity in preterm infants may result in a lower chance of successful breastfeeding compared to full-term infants [32, 33]. We also observed this correlation in our research. Among the preterm infants surveyed, 43% of the babies were fed exclusively with their mother's milk in the first 6 months of life. In contrast, in our analogous study of full-term babies, 60% of them were fed according to current recommendations with mother's milk in the first 6 months of life [8].

Comparative analysis of psychomotor development at 12 months of age between the analyzed preterm infants and full-term newborns showed no differences in both the breastfed and formula-fed groups. The literature on the comparative analysis of psychomotor development in late preterm infants (34–36 6/7 weeks of gestation) and full-term newborns is inconsistent. This inconsistency is attributed to differences in clinical practice, changes in perinatal care over the years, and difficulties in study design. Some studies report delays in various aspects of psychomotor development in late preterm infants compared to full-term newborns [34, 35]. On the other hand, an analysis of the National Institute of Child Health and Development Study of Early Child Care and Youth Development did not find differences in cognitive functions, achievements, social skills, or behavioural/emotional problems from 4 to 15 years of age between late preterm infants and full-term infants [36]. Additionally, a cohort study showed that individuals born as late preterm infants in the 1970s and early 1980s did not have an increased risk of learning disabilities or attention deficit hyperactivity disorder (ADHD) compared to term-born individuals [37]. Our study focused on moderate preterm infants (32–36 6/7 weeks of gestation) vs. full-term infants, assessed at 12 months of age, taking into account the feeding method. The absence of delays in the eight psycho-

motor domains in these two groups suggests that preterm infants born after 32 weeks of gestation are able to catch up to full-term newborns at 12 months of age. This observation complements the existing literature and calls for further research in this aspect.

The analysis of physical development at 12 months of age in moderate preterm infants and full-term newborns showed no differences in both the breastfed and formula-fed groups. This suggests that preterm infants born after 32 weeks of gestation are able to catch up to full-term newborns at 12 months of age and do not exhibit growth limitations compared to full-term infants. This is an interesting observation that complements the current literature because there is limited literature specifically comparing these two groups of infants at 12 months of age. Studies show that extremely preterm infants (< 28 weeks) have lower measurements in the future compared to full-term infants [38, 39], but the observation regarding moderate and late preterm infants requires further research.

In our previous analysis evaluating the psychomotor development of full-term newborns based on the feeding method [8], we observed better development of social skills in breastfed infants compared to formula-fed infants. In the current analysis of preterm infants, we did not observe such a correlation. The reasons for this phenomenon may be attributed to the comprehensive developmental stimulation applied to preterm infants in accordance with recommendations in our department. This includes proper positioning, appropriate care, minimizing unpleasant experiences related to excessive lighting or noise, physiotherapeutic and neurologopedic care, as well as active involvement of parents in caring for the child from birth. It is possible that all of these factors contribute to the stimulation of preterm infants from birth, surrounded by the engagement of family and medical personnel, which prevents limitations in establishing relationships with both familiar and unfamiliar individuals, which are assessed in the eighth domain of the MFDD scale. The studied group of preterm infants above 32 weeks of gestation consists of moderately and late preterm infants who, compared to extremely preterm infants (< 28 weeks), typically do not require prolonged and highly intensive care. These children can be kangarooed by their mothers relatively quickly and establish a bond with them. Additionally, this group has a lower risk of complications associated with prematurity compared to extremely preterm infants. One of such complications is early childhood autism, which would cause delays in social skill development. All of this suggests that the group of studied preterm infants > 32 weeks of gestation not only catches up to full-term newborns but also, despite being formula-fed, does not develop limitations in social skills, as observed in full-term newborns.

Conclusions

Among children born prematurely in 32–36 6/7 weeks of gestation, neurological examination using the MFDD scale at 12 months of corrected age demonstrated no statistically significant difference in the range of deviations in gross and fine motor skills, perception, active and passive speech and at the level of social skills between breastfed and formula-fed children. Among the preterm infants studied, 43% were exclusively breastfed until 6 months of age or longer, in line with current recommendations. The preterm infants whose mothers suffered from gestational hypertension received prenatal steroid therapy and magnesium sulphate were formula fed more frequently. The mothers of preterm infants with higher education are more likely to feed their children exclusively with breast milk until at least 6 months of age, according to recommendations. Children born prematurely in 32–36 6/7 weeks of gestation do not show differences in psychomotor development assessed using the MFDD scale, nor do they show differences in weight and head circumference gains (at 12 months of corrected age) compared to full-term newborns.

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Ethical approval

The study was approved by the Bioethics Committee at Jan Kochanowski University in Kielce (under bioethics committee resolution No. 14/2016).

Conflict of interest

The authors declare no conflict of interest.

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