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ORIGINAL ARTICLE

Risk factors for malnutrition at two years of corrected age in preterm infants under 32 weeks

Factores de riesgo de malnutrición a los dos años de edad corregida en prematuros menores de 32 semanas al nacer

Patricia Vernal Silva[a], Patricia Mena Nannig[b], Alexis Diaz Gonzalez[c], Maria Teresa Henriquez Höfter[d], Enrica Pittaluga Pierdiluca[b], Ivonne D'Apremont Ormeño[b], Monica Morgues Nudman[a], Jane Standen[e], Karla Johannessen Vasquez[f]

[a]Unidad de Neonatología, Hospital San Jose. Santiago, Chile.
[b]Servicio de Neonatología, Hospital Sotero del Rio. Santiago, Chile.
[c]Unidad de Neonatología, Hospital de Rancagua. Santiago, Chile.
[d]Unidad de Neonatología Hospital San Juan de Dios. Santiago, Chile.
[e]Unidad de Neonatología, Hospital Gustavo Fricke. Valparaíso, Chile.
[f]Departamento de Pediatría y Cirugía Infantil, Facultad de Medicina, Universidad de Chile. Santiago, Chile.

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What do we know about the subject matter of this study?

Nutritional evolution in preterm infants has been associated with poor weight gain and increased risk of in-hospital and postnatal malnutrition.

What does this study contribute to what is already known?

This study allows anticipating the risk of deficit or excess malnutrition at two years considering birth weight and body mass Z-score at 6 months, in a population of very preterm infants with a postnatal feeding program with nutrient-enriched formulas.

Abstract

Post-discharge nutrition of preterm newborns must avoid excessive or insufficient weight gain and optimal length and head circumference growth. In Chile, premature infants less than 32 weeks at birth receive fortified formulas during the first year, unless they are exclusively breastfed. **Objective:** To describe growth and identify the risk of malnutrition at 24 months. **Patients and Method:** Retrospective cohort study that analyzes growth from birth to 2 years of corrected age in preterm patients < 32 weeks of gestational age. Z-score of weight, length, head circumference, and Body Mass Index (BMI) were analyzed. Factors related to Z BMI at 24 months were analyzed

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Correspondence:
Patricia Vernal
lavermed@vtr.net

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Lillian Bolte Marholz

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as follows: Eutrophic: Z BMI between -1 and +1; Overweight: Z BMI > +1; Underweight: Z BMI < -1. **Results:** 996 preterm infants were included, 559 completed check-ups at 24 months. 64.5% were eutrophic, 18.4% overweight, and 17.1% underweight. Multivariate analysis showed that risk of overweight was associated with birth weight > 1460 g: OR 5.77 (2.11-15.77) and Z BMI > 1.6 at 6 months: OR 2.67 (1.91-3.74); underweight risk was associated with birth weight < 1000g: OR 3.1 (1.1-8.8) and Z BMI < -0.75 at 6 months: OR 8.2 (4.3-16.3). **Conclusions:** The greater risk of overweight and underweight can be anticipated in premature infants under 32 weeks with birth weight or Z BMI at 6 months of corrected age.

Introduction

Nutritional care is one of the fundamental aspects of care during hospitalization and after discharge of the preterm infant to promote adequate growth and development[1,2]. Difficulties in adequate nutrition along with the morbidity of the premature infant frequently determine inadequate postnatal growth. The term extrauterine growth restriction (EUGR) has emerged, which refers to the measurement of the percentage of patients who at discharge weight below the 10th percentile of an intrauterine growth curve[3,4]. In the last 15 years, there have been important modifications in neonatal nutritional support, with early initiation and increased nutrient intake, which has progressively reduced EUGR and improved nutritional status at discharge[5].

The decrease in EUGR, with linear and head catch-up growth in the first months, has been clearly associated with improved neurocognitive development[6-10]. Different follow-up and nutritional intervention studies indicate that there is a window of opportunity to recover head growth, with developmental benefits, up to 3 to 4 months of corrected age (CA) for appropriate-for-gestational-age (AGA) preterm infants, and up to 1 year in small-for-gestational-age (SGA) preterm infants[11,12].

Both with intrauterine growth restriction (IUGR) and EUGR, the preterm infant can produce an adaptive response to malnutrition with a thrifty metabolism that favors nutritional recovery, but that by reprogramming gene expression can favor the risk of insulin resistance, obesity, and chronic diseases in the long term[13-15].

In Chile, since 2003, the National Complementary Feeding Program for preterm infants (PNAC preterm) of the Ministry of Health has been in place. This is a universal benefit that provides milk formula for preterm infants with GA < 32 weeks or birth weight < 1500 grams who are not exclusively breastfed, from discharge until 6 months of CA, and a continuation formula until one year of age. In those who were born weighing less than 1000 grams or developed bronchopulmonary dysplasia (BPD), the preterm formula is extended until one year of CA[16] (table 1).

Current studies have related the higher intake of milk proteins during the first year of life with a higher risk of later infant obesity[17,18], which in the country is a public health problem[19,20]. As preterm formulas contain a 40% higher concentration of protein than term infant formulas[21] and it has been seen that preterm infants younger than 32 weeks are evolving with better postnatal nutrition, it is relevant to explore the risk of malnutrition in the preterm population.

The objective of this study is to evaluate the anthropometric evolution of a cohort of preterm infants beneficiaries of the PNAC in the first 2 years of corrected age and to identify early factors for the risk of either excess or deficit malnutrition at 2 years.

Patients and Method

Retrospective cohort study of preterm infants under 32 weeks born between January 1, 2011, and December 31, 2012, from 5 health centers of the Chilean Public Health System in the Metropolitan Region, Viña del Mar, and Rancagua. The control population corresponds to low and medium-low socioeconomic levels.

All preterm infants admitted to the 5 follow-up healthcare centers during the study period were considered. Preterm infants with genetic diseases that affect growth and those who did not attend more than 3 check-ups or the 24-month check-up were excluded.

Anthropometric information was obtained from the follow-up healthcare center's records. Weight was evaluated on the periodically adjusted scales of each center. The length was measured in the supine position between 2 persons and head circumference (HC) with the highest occipitofrontal diameter value, with a non-extensible measuring rod.

The diagnosis of bronchopulmonary dysplasia (BPD) was included, defined as requiring additional oxygen for 28 days; this was one of the criteria of the PNAC for premature infants that determines the pro-

Table 1. National complementary feeding program for preterm babies under 32 weeks or under 1500 g at birth

Criterion	Preterm formula	Follow up formula
≤ 1000 g birth weight or BPD	Discharge up to 12 month corrected age	
> 1000 g birth weight	Discharge up to 6 month corrected age	6 month up to 12 month corrected age

BPD: bronchopulmonary dysplasia.

longation of formula administration for premature infants from 6 to 12 months.

The Anthro software was used to determine the anthropometric Z-score, according to sex and date of check-ups[22]. In the first semester check-ups, a range of +15 days was used to add to that age the check-up performed, and subsequently, a range of 1.5 months was considered for the same addition. The calculation with the Anthro system was performed with the exact corrected age at the time of the check-up, corrected to 40 weeks [Postnatal age in weeks at check-up - (40 weeks gestational age at birth)].

Check-ups were performed at 40 weeks, 1,3,6,9,12,15,18, and 24 months of CA.

Nutritional status groups were established at 2 years according to body mass index (BMI) Z-score and classified into:

1. Eutrophic: normal Z-BMI (Z-score -1 to +1).
2. Risk of malnutrition due to excess: Z-BMI (Z score > 1).
3. Risk of malnutrition due to deficit: Z-BMI (Z score < -1).

Statistical analysis

Z-scores were calculated with Anthro software for each check-up[22]. The anthropometry of the groups that at 2 years had a weight-for-age greater or less than one SD (Z score > 1 or < -1), were analyzed from their 40 weeks, looking for which check-up and which value was significantly associated with malnutrition.

The anthropometric values of these three groups in the check-ups were compared with ANOVA. In those check-ups with anthropometric values with statistically significant difference ($p < 0.05$), linear regression and correlation analysis were performed between the value at check-up and two years.

The univariate analysis included birth weight (BW), growth velocity from 40 weeks to 1 month and 1 month to 3 months, Z-BMI in the first 6 months, and BPD status in relation to malnutrition status at 2 years. Subsequently, a multivariate logistic regression analysis was performed with the significant variables and the risk of malnutrition at 2 years.

Descriptive, quantitative statistics were used with Anova, Mann-Whitney test, Kruskal-Wallis test, according to variable distribution, and categorical ones with chi-square; Pearson correlation, uni- and multivariate analysis, and logistic regression. A $p < 0.05$ was considered significant. The analysis was performed with the Stata11.1 software.

The study was approved by the Ethics and Research Committee of the South-East Metropolitan Health Service in March 2021. The data were anonymized.

Results

Of the 996 patients included, 559 (56%) were analyzed since they comply with the 2-year check-up and had less than 3 absences. The number controlled varied at each check-up, despite the relatively wide range of one and a half months after 3 months.

Table 2 shows the anthropometric characteristics at birth, discharge, 40 weeks, and one month, sex, and the frequency of SGA and BPD of the group included and the one not included. There were no significant differences in any of the characteristics analyzed.

Figure 1 describes the anthropometric evolution of weight/age Z-score, length/age Z-score, and BMI/age Z-score during follow-up. The average weight Z-score and BMI Z-score are around the mean (Z = 0 + 1), but with a wide SD (> 1). The length/age Z-score slowly recovers from the lower value at 3 months of corrected age (-0.87).

Table 3 shows early anthropometry according to BMI Z-score at 24 months. The difference in birth weight in mean and SD between the three groups stands out. There are no differences in gestational age at birth or anthropometry at discharge. The history of BPD is higher in the deficit malnutrition risk group. The adequacy at birth shows a higher percentage of SGA and birth weight < 1000 g in the deficit malnutrition risk group.

Figure 2 shows the evolution of BMI Z-score during the study period of the eutrophic group and the groups with deficit and excess malnutrition. Of the preterm infants, 64.5 % were eutrophic according to BMI Z-score at 24 months, 17.1 % were at risk of deficit malnutrition, and 18.4 % were at risk of excess malnutrition according to the same parameter. Each of the BMI Z-score curves shows statistically significant differences in Z-score value by check-up, starting at 40 weeks.

BPD was a factor for lower risk of excess malnutrition at 24 months; it was significant in the univariate model (OR 0.48; CI 0.26 - 0.89), and for higher risk of deficit malnutrition (OR 1.55; CI 1.0 - 2.42), but in both cases, BPD loses significance in the adjusted model.

Higher growth velocity in grams per day, between 40 weeks corrected age and 1 month and between 1 month and 3 months were associated with higher risk of excess malnutrition (OR 1.1; CI 1.02 - 1.12; P 0.001 and OR 1.1; CI 1.03 - 1.12; P 0.0001, respectively).

BMI Z-score in check-ups at 1, 2, 3, and 4 months was positively associated with BMI Z-score at 24 months. The correlation of BMI Z-score at 24 months and 40 weeks was R = 0.33, R = 0.41 at 1 month, R = 0.53 at 3 months, and R = 0.58 at 6 months.

In the logistic regression analysis (table 4), the significant risk factors for excess malnutrition were birth weight > 1460 g (OR 5.77; CI 2.11-15.77; p < 0.001) and BMI Z-score > 1.6 at 6 months (OR 2.67; CI 1.91-3.74; p < 0.001). The significant risk factors for deficit malnutrition were birth weight < 1000g (OR 3.1; CI 1.1- 8.8; p 0.03) and BMI Z-score at 6 months < -0.75 (OR 8.3; CI 4.3 - 16.3; p < 0.001). Table 5 shows the values corresponding to the lower quartile.

Discussion

The analysis of growth of this cohort of preterm infants, supplemented in the post-hospital discharge follow-up according to the PNAC preterm criteria, allowed us to identify risk factors for malnutrition at 2 years of age. Thus, birth weight > 1460 grams can be a cut-off value for attention to the risk of excess malnutrition. A birth weight < 1000 grams is associated with a higher risk of deficit malnutrition.

As seen in the tables and figures, BMI Z-score at 40 weeks and 1 month and between 1 month and 3 months and higher growth velocity between these check-ups are associated with higher risk of excess malnutrition at 2 years. A growth rate ≥ 30 g/day after the first month of corrected age and BMI Z-score at 6

Table 2. Included and not included group characteristics

	Included group 24 month up	Not included	
n	559	437	
Gestational age, weeks	29.6 (2.3)	29.4 (2.4)	NS
Female	46.8	45.1	NS
Birth weight, kg	1.246 (0.382)	1.268 (0.372)	NS
Birth length, cm	37.8 (3.5)	37.5 (3.8)	NS
Head circumference, cm	27.2 (2.5)	27.2 (2.4)	NS
Weight at discharge, kg	2.69 (0.69)	2.81 (0.80)	NS
Length at discharge , cm	46.5 (3.7)	46.9 (3.8)	NS
Head circumference at discharge, cm	33.6 (2.2)	33.9 (2.5)	NS
Weight at 40 weeks, kg	3.21 (0.69)	3.26 (0.66)	NS
Length at 40 weeks, cm	48.67 (2.56)	48.79 (2.52)	NS
Head circumference at 40 weeks, cm	35.32 (1.69)	35.37 (1.75)	NS
Weight at 1 month CA, kg	4.15 (1.04)	4.31 (0.87)	NS
Length at 1month CA, cm	52.61 (2.70)	52.82 (2.88)	NS
Head circumference at 1 month CA, cm	37.52 (1.61)	37.72 (1.72)	NS
Age at discharge, days	58 (40-82)	59 (40-94)	NS
Bronchopulmonary Dysplasia %	38.1	37.4	NS
Small for gestacional age %	35.7	31.2	NS

CA: corrected age; NS: not significant.

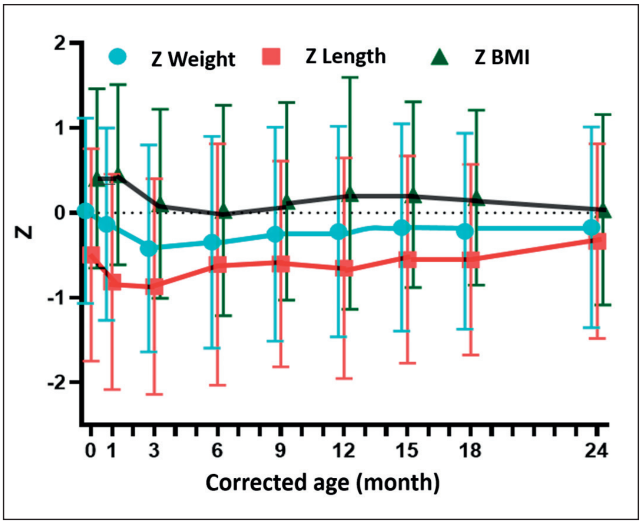

Figure 1. Weight, length and BMI Z score evolution from 40 weeks up to 24 month of corrected age (average ± standard deviation).

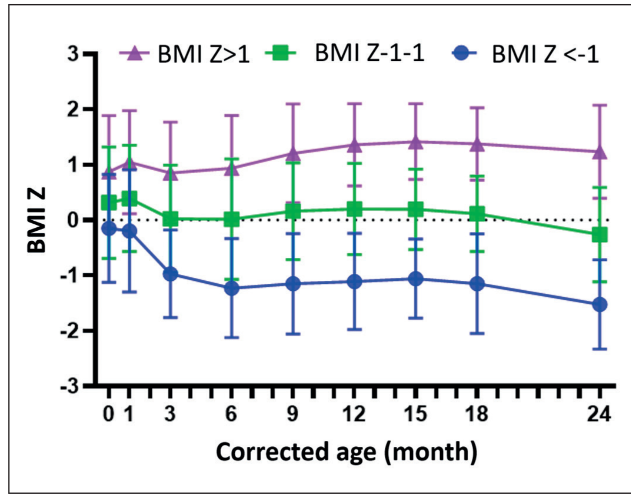

Figure 2. Body Mass Index Z score evolution during the first 2 years of corrected age, according to the BMI Z established at 24 month: Eutrophic (BMI Z ±1), excess malnutrition risk (BMI Z >1), deficit malnutrition risk (BMI Z <-1). (average ± SD).

Table 3. Antropometry and general characteristics according to BMI Z-score at 24 month of corrected age

	Deficit Malnutrition risk: BMI Z <-1	Eutrophy BMI Z >-1 <1	Excess malnutrition risk BMI Z > 1	P
n	95	358	102	
Birth weight, g	1126 (315)	1276 (320)	1465 (310)	< 0.001
Birth length, cm	36.9 (3.6)	37.9 (3.2)	39.3 (2.7)	< 0.001
Birth head circumference, cm	26.5 (2.1)	27.1 (2.2)	28.3 (2.3)	< 0.001
Gestational age, weeks	29.3 (2.3)	29.6 (2.3)	29.8 (1.8)	0.351
Female (%)	34.7	50.0	43.1	0.024
Bronchopulmonary Dysplasia (%)	52.9	45	30.2	0.003
Birth weight <1000g (%)	40.2	26.0	9.8	< 0.001
Small for GA (%)	41.4*	26.6	25.4	*< 0.001
Large for GA (%)	3.45	5.26	5.83	0.132
Weight at discharge, g	2736 (857)	2664 (633)	2740 (743)	0.466
Length at discharge, cm	46.9 (4.3)	46.4 (3.03)	46.6 (3.1)	0.529
Head circumference at discharge, cm	33.7 (2.9)	33.4 (2.01)	33.3 (2.2)	0.435

Data in % and average and (standard deviation); GA gestational age.

months > 1.6 are risk factors for excess malnutrition, which could be considered in nutritional surveillance for possible interventions in nutritional intake. According to the PNAC, a preterm infant with this evolution and history of BPD would continue to receive a high-protein preterm formula until one year of age. On the other hand, having a birth weight < 1000 g and having a BMI < -0.75 are risk factors for deficit malnutrition. In this case, continuing with a preterm formula until one year of age would be appropriate.

Several post-discharge nutritional intervention studies have shown that formula intake is regulated by the infant according to energy concentration[23]. Providing a more concentrated formula or only with added energy to a milk formula does not modify the postnatal evolution[23]. Studies with a higher concentration of proteins and microelements than energy do not have a greater change in weight evolution, but they do in longitudinal growth and accumulation of fat-free mass[24]. Formulas for premature infants have approximately

Table 4. Logistic regression analysis for BMI Z> 1

	OR	CI	P
Birth weight > 1460 g	5.77	2.11 - 15.77	0.001
Growth weight velocity > 30 (g/day) between 1 - 3 month	1.01	0.96 - 1.06	0.680
BMI Z at 6month > +1,6	2.67	1.91 - 3.74	< 0.001
Bronchopulmonary Dysplasia	0.68	0.34 - 1.32	0.258

BMI: Body Mass Index.

Table 5. Logistic regression analysis BMI Z < -1

	OR	CI	P
Birth weight < 1000 g	3.12	1.11 - 8.81	0.031
Growth weight velocity lower quartile between 1 - 3 month	0.87	0.43 - 1.7	0.705
BMI Z at 6 month < -0,75	8.34	4.26 - 16.32	< 0.000
Bronchopulmonary Dysplasia	0.84	0.41 - 1.73	0.646

BMI: Body Mass Index.

40% more protein and 17% more energy than the starter formula and are very adequate to continue post-discharge in premature infants with a need for recovery in nutritional status[19]. The higher protein/energy ratio directly favors linear growth, head circumference growth, and increased lean mass deposition in the preterm infant[24,25].

The long-term effects of insufficient pre- or post-natal growth are epigenetically mediated, favoring the presentation of chronic diseases in adulthood. Insulin resistance is detected early, in the first and second years of life[13]. Metabolic syndrome, cardiovascular risk, and arterial hypertension are more frequent than in the general population, both with a history of IUGR and EUGR and with subsequent catch-up growth. Depending on these variables and the sex of the child, there are different degrees of risk of these pathologies[13-15].

In this study, the differences by sex were not relevant, but differences have been described in growth from the prenatal period and in the postnatal period during intrahospital and post-discharge growth, as well as effects on morbidity. In general, the effects of nutritional interventions are observed in males but not in females[26]. The effects on the improvement of length, HC, and lean mass in the short term are only observed in the male group[24].

BPD defined as oxygen requirement for 28 days is associated with higher risk of deficit malnutrition and lower risk of excess malnutrition, but it is significant only in the univariate model and disappears in the logistic regression model. Also, it has no predictive value for malnutrition or unfavorable outcome[27]. Current international definitions of BPD do not include this definition[27]. Oxygen requirements up to 36 weeks in infants with gestational age > 30 weeks may anticipate respiratory and nutritional compromise[28]. A change in the definition of BPD as given at the international level would allow targeting an intervention more appropriately.

An important weakness of this study is the decrease in the number of patients in follow-up between admission to follow-up and two years of CA, which excluded a significant number of cases from the analysis. Formal follow-up is extended to 7 years, but the population attending continues to gradually decrease. Having only anthropometric data, without information on the food received and the morbidity presented is an important limitation. There is also no data on the duration of breastfeeding, which should be a fundamental aspect in hospital and post-discharge care of premature infants since it reduces long-term metabolic and neurocognitive risk[29].

The strength of this study is the number of subjects from 5 centers in the country, monitored in the first 2 years of life. Also, the description of anthropometric levels and growth velocity of malnutrition risk would allow intervention in the nutritional intake. Adequate nutrition after 3 months of CA does not produce greater cognitive risk and reduces the risk of excess malnutrition[11,12].

Controlling dairy and non-dairy diets and physical activity are required to achieve a healthy lifestyle in this group which is especially vulnerable to nutritional and metabolic problems. Prematurity is not only a patient at risk for neonatal morbidity that can be severe but has physical and behavioral differences throughout life that require monitoring and early referral for complications[30].

Conclusion

The risk of malnutrition at 24 months with BMI Z-score > 1 or < -1 can be anticipated in preterm infants younger than 32 weeks. Preterm infants with birth weight > 1460 g or presenting BMI Z-score > 1.6 at 6 months of CA are at increased risk of excess malnutrition. These parameters would allow modification of nutritional intake and individual check-ups for adequate growth. The risk of deficit malnutrition is associated with birth weight < 1000 g and BMI Z-score < 0.75 at 6 months.

Based on this study, nutritional surveillance incorporating the elements described above and the evaluation of the evolution beyond two years, including the preschool period, should be considered.

Ethical Responsibilities

Human Beings and animals protection: Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

Data confidentiality: The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

Rights to privacy and informed consent: The authors have obtained the informed consent of the patients and/or subjects referred to in the article. This document is in the possession of the correspondence author.

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

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References

1. Harding J, Cormack B, Alexander T, et al. Advances in Nutrition of the Newborn Infant Lancet 2017;389:1660-8.
2. McKenzie B, Edmonds L, Thomson B, et al. Nutrition Practices and Predictors of Postnatal Growth in Preterm Infants During Hospitalization: A Longitudinal Study J Pediatr Gastroenterol Nutr. 2018;66:312-7.
3. Clark RH, Thomas P, Peabody J. Extrauterine growth restriction remains a serious problem in prematurely born neonates. Pediatrics 2003;111:986-90.
4. Azara P, Lima T, Carvalho M, et al. Variables associated with extrauterine growth restriction in very low birth weight infants. J Pediatr. (Rio J) 2014;90:22-7.
5. Horbar JD, Ehrenkranz RA, Badger GJ, et al. Weight Growth Velocity and Postnatal Growth Failure in Infants 501 to 1500 Grams: 2000-2013. Pediatrics. 2015;136:e84-92.
6. Ramel S, Christiansen E, Boys C, et al. Greater early gains in fat-free mass, but not fat mass, are associated with improved neurodevelopmental 1-year corrected age for prematurity in very low birth weight preterm infants. J Pediatr 2016;173:108-15.
7. Guellec I, Lapillonne A, Marret S, et al. Effect of intra- and extrauterine growth on long-term neurologic outcomes of very preterm infants. J Pediatr. 2016;175:93-9.e91.
8. Sammallahti S, Pyhälä R, Lahti M, et al. Infant Growth after Preterm Birth and Neurocognitive Abilities in Young Adulthood. J Pediatr. 2014;165:1109-15.
9. Strømmen K, Blakstad E, Moltu S, et al. Enhanced Nutrient Supply to Very Low Birth Weight Infants is Associated with Improved White Matter Maturation and Head Growth. Neonatology 2015;107:68-75.
10. Tottman A, Bloomfield F, Cormack B, et al. Sex-specific Relationships Between Early Nutrition and Neurodevelopment in Preterm Infants. Pediatr Res. 2020;87(5):872-8.
11. Belfort M, Gillman M, Buka S, et al. Preterm Infant Linear Growth and Adiposity Gain: Trade-Offs for Later Weight Status and Intelligence Quotient. J Pediatr. 2013;163:1564-9.
12. Lafeber H, van de Lagemaat M, Rotteveel J, et al. Timing of nutritional interventions in very-low-birth-weight infants: optimal neurodevelopment compared with the onset of the metabolic syndrome. Am J Clin Nutr 2013;98(suppl):556S-60S.
13. Pittaluga E, Vernal P, Llanos A, et al. Benefits of Supplemented Preterm Formulas on Insulin Sensitivity and Body Composition after Discharge from the Neonatal Intensive Care Unit. J Pediatr. 2011;150:926-32.
14. Matinolli HM, Hovi P, Levälahti E, et al. Neonatal Nutrition Predicts Energy Balance in Young Adults Born Preterm at Very Low Birth Weight. Nutrients 2017;9:1282.
15. Embleton ND, Korada M, Wood CL, et al. Catch-up growth and metabolic outcomes in adolescents born preterm. Arch Dis Child 2016;101:1026-31.
16. https://www.minsal.cl/wp-content/uploads/2016.04.20-Norma-Técnica-Prog.-Alimentarios-aprobada-por-Jurídica.
17. Weber M, Grote V, Closa-Monasterolo R, et al for The European Childhood Obesity Trial Study Group. Lower protein content in infant formula reduces BMI and obesity risk at school age: follow-up of a randomized trial1-5 Am J Clin Nutr. 2014;99:1041-51.
18. Koletzko B, Demmelmair H, Grote V, et al. Optimized protein intakes in term infants support physiological growth and promote long-term health. Sem Perinatol. 2019;43:151153.
19. OPS/OMS, Salud en Chile 2010. Panorama de la situación de salud y del sistema de salud en Chile, Documento de Análisis de Situación, Santiago de Chile 2011. Disponible en: http://new.paho.org/chi/images/PDFs/salud%20chile%202010.pdf. Obesidad infantil en Chile.
20. Han J , Jiang Y, Huang J, et al . Postnatal growth of preterm infants during the first two years of life: catch up growth accompanied by risk of overweight. Ital J Pediatr. 2021;47-66.
21. Cooper PA, Rothberg AD, Davies VA, et al. Comparative growth and biochemical response of very low birthweight infants fed own mother's milk, a premature infant formula, or one of two standard formulas. J Pediatr Gastroenterol Nutr. 1985;4:786-94.
22. WH0 Multicenter Growth Reference Study Group: WHO Child Growth Standards. Acta Pediatr Suppl. 2006;450:5-101.
23. Cooke R, McCormick K, Griffin I, et al. Feeding preterm infants after hospital discharge: effect of diet on body composition. Pediatr Res. 1999;46:461-4.
24. Teller IC, Embleton ND, Griffin IJ, et al. Post-discharge formula feeding in preterm infants: A systematic review mapping evidence about the role of macronutrient enrichment. Clin Nutr. 2016;35:791-801.
25. Amesz E, Schaafsma A, Cranendonk A, et al. Optimal Growth and Lower Fat Mass in Preterm Infants Fed a Protein-enriched Postdischarge Formula. JPGN 2010;50:200-7.
26. Alur P. Sex Differences in Nutrition, Growth, and Metabolism in Preterm Infants. Front Pediatr. 2019;7:22.
27. Gillfillan M, Bhandari A, Bhandari V. Diagnosis and management of bronchopulmonary dysplasia British Med J. 2021;375:n1974.
28. Jensen E, Dysart K, Gantz M, et al. The diagnosis of bronchopulmonary dysplasia in very preterm infants. An evidence-based approach. Am J Respir Crit Care Med 2019; 200:751-9.
29. Boquien CY. Human Milk: An Ideal Food for Nutrition of Preterm Newborn. *Front Pediatr*. 2018;6:295.
30. Raju T, Buist S, Blaisdell C, et al. Adults born preterm: a review of general health and system-specific outcomes. Acta Pædiatrica 2017;106:1409-37.