

Head circumference growth of exclusively breastfed infants during the first six months of life

Crescimento do perímetro cefálico nos primeiros seis meses em crianças em aleitamento materno exclusivo
Crecimiento del perímetro cefálico en los primeros 6 meses en niños en lactancia materna exclusiva

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ABSTRACT

Objective: To analyze the head circumference growth of exclusively breastfed children from birth to the sixth month of life using, as references, the National Center for Health Statistics (NCHS/1977) as well as the World Health Organization/2006 international standard (WHO/2006).

Methods: A longitudinal research carried out at the Mother and Child University Hospital of the Federal University of Maranhão (Northeast Brazil), from October 2007 to November 2008. A non-probabilistic sample of 328 singleton full term neonates, with birthweight ≥ 2500 g and ≤ 4000 g was enrolled, being all neonates exclusively breastfed from birth to the sixth month of life; 181 children (95 females and 86 males) completed the follow-up. The head circumference was estimated by average, standard deviation and percentiles 5, 50 and 95. Percentile results were compared taking as references the NCHS/1977 and the WHO/2006 standards.

Results: There was an average of 1.5cm in head circumference growth for males and 1.4cm for females per month during the first six months of life. Head circumference followed the 50th percentile of the WHO/2006 standard for both genders. Regarding the NCHS/1977 standard, males presented head circumference following the 50th percentile throughout the six months, except at birth, and females followed the 50th percentile from birth until six months of life.

Conclusions: Exclusively breastfed children presented a satisfactory head circumference growth up to the sixth month of life, in accordance with the 50th percentile of WHO/2006 and NCHS/1977 standards.

Key-words: breast feeding; cephalometry; growth; anthropometry.

RESUMO

Objetivo: Analisar o perímetro cefálico de crianças amamentadas exclusivamente do nascimento ao sexto mês com relação à referência *National Center for Health Statistics* (NCHS/1977) e ao padrão internacional *World Health Organization/2006* (WHO/2006).

Métodos: Estudo longitudinal realizado no Banco de Leite Humano do Hospital Universitário Materno-Infantil, São Luís (MA), entre outubro de 2007 e novembro de 2008. Amostra não probabilística de 328 crianças nascidas a termo, parto único, peso ao nascer ≥ 2500 g e ≤ 4000 g, em aleitamento exclusivo do nascimento ao sexto mês. Finalizaram o estudo 181 crianças (95 meninas e 86 meninos). Avaliou-se o perímetro cefálico por meio de média, desvio padrão e percentis 5, 50 e 95. Os resultados em percentis foram comparados aos da referência NCHS/1977 e do padrão WHO/2006.

Resultados: Nos primeiros seis meses, houve um aumento do perímetro cefálico, em média, de 1,5cm por mês nos meninos e de 1,4cm nas meninas. O crescimento do perímetro cefálico, em ambos os sexos, acompanhou o percentil 50 do padrão WHO/2006. Nos meninos, exceto ao nascer, o percentil 50 do perímetro cefálico foi equivalente ao da referência NCHS/1977; nas meninas, situou-se próximo desde o nascimento.

Conclusões: As crianças em aleitamento materno exclusivo até o sexto mês de vida apresentaram crescimento satisfatório.

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tório do perímetro cefálico, em conformidade com o percentil 50 do padrão WHO/2006 e da referência NCHS/1977.

Palavras-chave: aleitamento materno; circunferência craniana; crescimento; antropometria.

RESUMEN

Objetivo: Analizar el perímetro cefálico de niños amamantados exclusivamente, desde el nacimiento hasta el sexto mes, respecto a la referencia *National Center for Health Statistics* (NCHS/1977) y al estándar internacional *World Health Organization/2006* (WHO/2006).

Métodos: Estudio longitudinal realizado en el Banco de Leche Humana del Hospital Universitario Materno-Infantil, São Luís, Maranhão, Brasil, entre octubre de 2007 y noviembre de 2008. Muestra no probabilística con 328 niños nacidos a término, parto único, peso al nacer igual o superior a 2,5kg e inferior o igual a 4,0kg y en lactancia exclusiva, desde el nacimiento hasta el sexto mes. Finalizaron el estudio 181 niños (95 niñas y 86 niños). Se evaluó el perímetro cefálico mediante promedio, desviación estándar y percentiles 5, 50 y 95. Los resultados en percentiles fueron comparados a los de la referencia NCHS/1977 y al estándar WHO/2006.

Resultados: En los primeros seis meses hubo un aumento del perímetro cefálico promedio de 1,5cm al mes en los niños y de 1,4cm en las niñas. El crecimiento del perímetro cefálico, en ambos sexos, acompañó el percentil 50 del estándar WHO/2006. En los niños, excepto al nacer, el percentil 50 del perímetro cefálico fue equivalente al de la referencia NCHS/1977; en las niñas, se situó cerca desde el nacimiento.

Conclusiones: Los niños en lactancia materna exclusiva hasta el sexto mes de vida presentaron crecimiento satisfactorio del perímetro cefálico, en conformidad con el percentil 50 del estándar WHO/2006 y de la referencia NCHS/1977.

Palabras clave: lactancia materna; perímetro cefálico; crecimiento; antropometría.

Introduction

Breastmilk is the most important source of nutrients for children during their first 6 months of life⁽¹⁾. The World Health Organization (WHO) recommends exclusive breastfeeding (EBF) throughout this period as the ideal nutrition for child development and growth⁽²⁾.

Monitoring children's growth in terms of head circumference at regular intervals makes it possible to determine whether cerebral development is within normal limits, since there

is a strong correlation between head circumference growth and cerebral development⁽³⁻⁶⁾. Studies support the hypothesis that human milk can make a difference to head circumference growth, due to the nutrients it contains, including iron and polyunsaturated long chain fatty acids which contribute to brain development^(3,7). Head circumference growth in children breastfed for long periods may be associated with improved psychomotor and mental development⁽³⁾.

The World Health Organization recommends that child growth be monitored using anthropometry⁽⁸⁾ and that anthropometric measurements should be compared to a reference standard, using growth curves⁽⁹⁾. Until recently, the growth curves recommended by the WHO for international use were those produced by the *National Center for Health Statistics* (NCHS)⁽¹⁰⁾. However, over the years a series of limitations were identified and they are now considered inadequate for breastfed children^(11,12). These limitations include the fact that they were based on anthropometric data taken from infants predominantly fed on infant formulas and measured at birth, during the first month and every 3 months thereafter⁽¹¹⁾. As a result, between 1997 and 2003, the WHO conducted a multicenter study designed to produce new curves for assessing the growth and development of children from zero to 5 years all over the world, irrespective of ethnic, cultural and socioeconomic factors or the type of feeding⁽¹³⁻¹⁵⁾. Among other characteristics, that study was based on observations of healthy babies on exclusive or predominant breastfeeding and whose mothers were not smokers^(13,14,16). This standard was based on the assumption that breastfeeding is the norm for ideal growth and the curves are recommended for all children, irrespective of whether or not they were breastfed⁽¹⁶⁾.

This study analyzes head circumference growth of breastfed children aged less than 6 months by comparing them to the 50th percentiles of the NCHS/1977 reference and of the new WHO/2006 standard.

Method

This was a longitudinal study conducted at the Human Milk Bank (HMB) at the *Hospital Universitário Materno Infantil* (HUMI), in São Luís, MA, Brazil, from October 2007 to November 2008. The HMB has been a state-level center of excellence on breastfeeding since 2004 and is part of the HUMI, which has been recognized as a Baby Friendly Hospital since 1998 and whose objective is fulfillment of the ten steps for successful breastfeeding.

In order to determine the necessary sample size, a pilot study was conducted with 30 children in order to obtain

estimates (mean and standard deviation) of the parameters under investigation and the sampling error. For all calculations, a 95% confidence interval and statistical power of 80% were assumed. Allowing for a 10% loss, the minimum estimated sample size was 185 children.

Inclusion criteria were as follows: full term children, single births, 5-minute Apgar ≥ 7 , birth weight ≥ 2500 g and ≤ 4000 g and EBF since birth. All infants were born at the HUMI and were kept with their mothers while in hospital. Exclusive breastfeeding was defined according to the 1991 WHO criteria⁽¹⁷⁾. An additional 27 children who were occasionally given water or teas because of colic while less than 1 month old were also included, but the children of smoking mothers and those who were unable to exclusively breastfeed for 6 months were not included in the study sample.

Children were selected by non-probabilistic sampling between October 2007 and June 2008 at their first consultation and at 1 month of age. At this point, mothers and children who fulfilled the study criteria were identified and the importance of the research and its inclusion criteria were explained to them. Mothers who agreed to take part signed free and informed consent forms and answered a questionnaire on identification, sociodemographic conditions, obstetric history, breastfeeding and details about their children.

Two nursing technicians were recruited from the HMB to conduct the head circumference measurements, together with the lead author. Team members were calibrated during a pilot study involving 30 children. Anthropometry was conducted according to standardized techniques and there was periodic cross-checking between the different professionals involved⁽¹⁸⁾. The measurements at the time of birth were acquired from the children's medical records or from the live births register. Head circumference was measured using an inelastic measuring tape^(3,19). Children were followed-up monthly from their first to their sixth months. The maximum interval allowed between each monthly anniversary and the follow-up consultation was ± 1 week for the first 4 months^(20,21) and ± 2 weeks after the fifth month⁽²⁰⁾. Each child was seen individually for anthropometry, to observe a breastfeed and for a clinical assessment by a pediatrician, always preceded by a lecture including information, encouragement and support for EBF. Family members were both allowed and encouraged to be present.

At each consultation, the mothers were asked what they fed their children, the number of breastfeeds every 24 hours, whether they were having any problems breastfeeding or any other health problems and what their vaccination status was. Exclusive breastfeeding was confirmed on the basis of information provided by the mothers and by observing correct technique when breastfeeding. Successive consultations were booked in

advance, but mothers were at liberty to return before the appointed dates if their children suffered any clinical conditions. Children were discharged from the study at 6 months of age and their mothers were told about complementary feeding and about maintaining breastfeeding until at least 2 years of age.

Children were excluded from the study if they did not attend the monthly appointments or if they were given other foods before 6 months. The research project was analyzed and approved by the Research Ethics Committee at the HUMI.

Head circumference measurements were expressed as means, standard deviations and the 5th, 50th and 95th percentiles. For the purposes of comparison, data were compared to the WHO/2006 standard, from birth up to 6 months⁽²²⁾ and the NCHS/1977 reference, at birth and at the first, third and sixth months⁽²³⁾. Statistics were produced using STATA 9.0 and a database stored in Epi INFO 2006, version 3.3.2.

Results

A total of 328 children on EBF were recruited, but just 181 of them, 95 (52.5%) girls and 86 (47.5%) boys, remained on the study until the end of their sixth month of life. The causes of the losses of 147 children from the sample are described in Figure 1.

Mean head circumference was larger for boys, from birth to 6 months, with a statistically significant difference at all ages ($p < 0.05$) (Table 1). Mean monthly increase in head circumference was 1.5cm for the boys and 1.4cm for the girls over the 6 months (data not shown). Table 2 lists the mothers' characteristics.

The 5th, 50th and 95th percentiles for the head circumference measurements for the children studied here were compared to the WHO/2006 standard and to the NCHS/1977

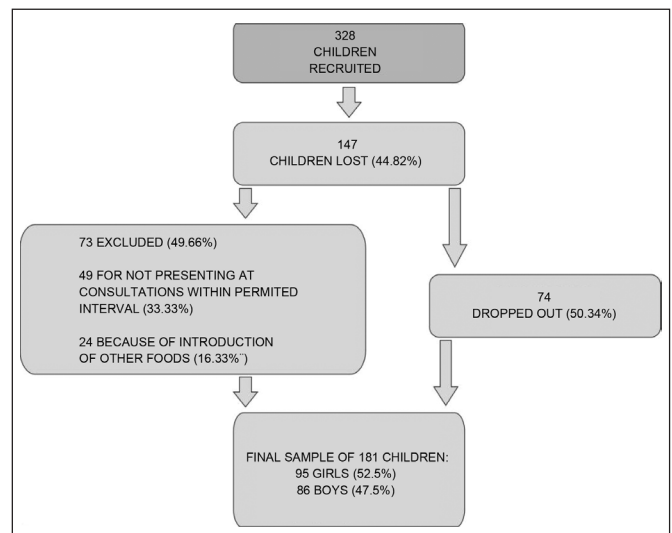


Figure 1 - Numbers of children recruited and followed to end of study

reference (graph 1a-b and 2a-b). It was observed that head circumference for both sexes followed the 50th percentile of the WHO/2006 standard for the first semester, with the girls slightly ahead of the reference curve after birth. For boys, the 50th percentile for head circumference was equivalent to the NCHS/1977 reference, except at birth; while for the girls it was close right from birth.

Table 1 - Mean head circumference measurements for children on exclusive breastfeeding, by sex and age, São Luís, MA, Brazil, 2008

Age	Boys (n=86)	Girls (n=95)	p
	Head circumference (cm)	Head circumference (cm)	
	Mean±SD	Mean±SD	
At birth	34.4±1.3	34.0±1.2	0.034
1 month	37.4±1.0	36.8±1.1	<0.001
2 months	39.2±1.0	38.6±1.0	<0.001
3 months	40.6±1.0	39.9±1.1	<0.001
4 months	41.7±0.9	40.9±1.1	<0.001
5 months	42.6±1.0	41.8±1.2	<0.001
6 months	43.4±1.1	42.6±1.2	<0.001

SD: standard deviation

Table 2 - Socioeconomic characteristics of the mothers of children on exclusive breastfeeding for the first 6 months of life. São Luís, MA, Brazil, 2008

Variables	number	%
Age group (years)		
<20	23	12.7
20 to 35	144	79.6
>35	14	7.7
Marital status		
Single	41	22.7
Married	67	37.0
Widowed	1	0.5
In a steady relationship	72	39.8
Educational level (years' study)		
≤8	32	17.7
9–11	132	72.9
≥12	17	9.4
Occupation		
Housewife	116	64.1
Domestic worker	9	5.0
Student	16	8.8
Others	40	22.1
Family income (minimum wage)		
up to 1	42	23.2
>1 to 4	98	54.1
>4	33	18.2
Did not know	8	4.4
Total	181	100.0

Discussion

Head circumference measurements are very important during the first year of life because they are an anthropometric parameter that is highly correlated with brain size^(4,6,24) and should therefore be routinely used for individual follow-up of children from zero to 24 months, which is the period of greatest postnatal growth^(4,25).

When mean head circumference was compared by sex, it was found that the boys had larger measurements throughout the first 6 months⁽²⁴⁾, but that the difference between means did not exceed 1cm, which is similar to what is described in the literature about the age group being studied here⁽²⁵⁾. This result is in line with what was observed by Donma and Donma⁽³⁾, in a study conducted in Turkey to determine the effect of type of feeding on head circumference in children over the first 6 months of life. The mean increases in head circumference over the first 6 months of 1.5cm per month for the boys and 1.4cm per month for girls was similar to the figures reported by Araújo⁽¹⁴⁾.

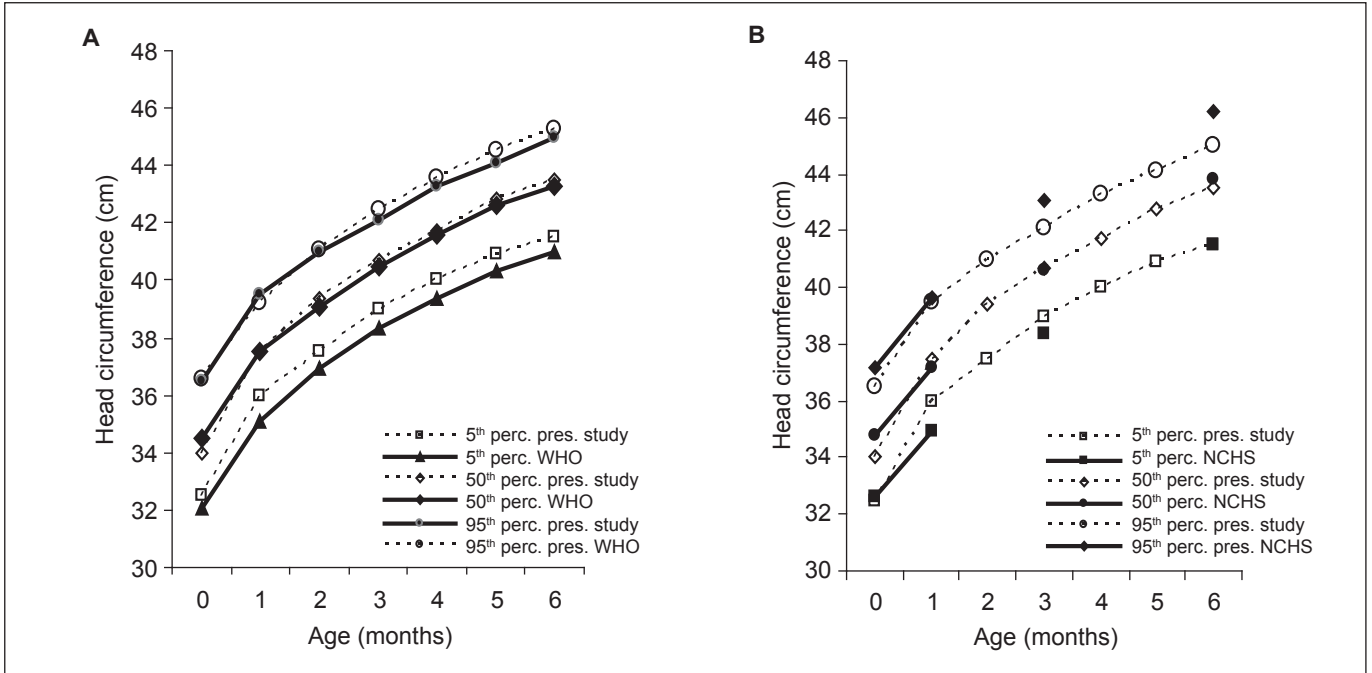
In both sexes, head circumference growth was comparable to the 50th percentile of the WHO/2006 standard and the NCHS/1977 reference. There was practically no variation between the head circumference results for the children studied here and the WHO/2006 standard and the NCHS/1977 reference. This result is in line with what has been reported, which is that head circumference is a measurement that varies little in any age group and that there is almost no variation associated with race, population or genetic factors⁽²⁵⁾.

In order to trace the velocity of head growth in early childhood, it is necessary to conduct systematic head circumference measurements and record them on a graph to produce a growth curve. This curve reflects the dynamics of overall growth of the skull and its internal structures. Serial measurements obviously make it easier to recognize disorders related to the speed of head growth as early as possible^(4,26). It must be stressed that at this age monitoring this particular anthropometric measurement is, in a wider sense, an accessible, simple and easy method of evaluating the normality of central nervous system development^(5,26). In the current study, there was a progressive increase in the ratio of head circumference to age, in both sexes, over the entire first semester, which is an observation that has been reported in other studies of exclusively breastfed children^(18,19).

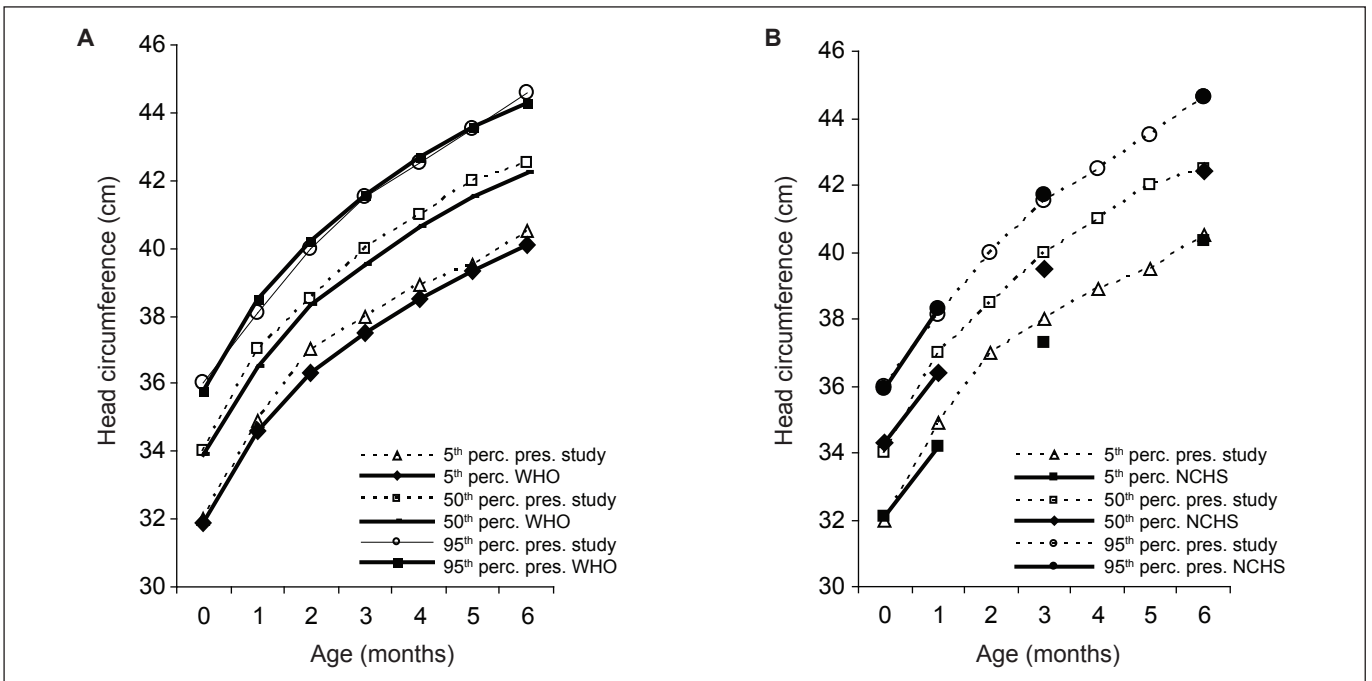
Growth in head circumference is fastest during the first 6 months of life, reaching a mean of 1.6cm/month^(18,19,27). It has been widely reported that at this age the nutrients present

in human milk, including phospholipids, polyunsaturated long chain fatty acids, iron and lactose, in addition to hormones and growth factors, are important for both cerebral growth^(3,7,28) and neuropsychomotor development^(28,29). In addition to nutrition, physical activity and stimulation also promote cerebral development⁽²⁸⁾. The study conducted by Donma and Donma⁽³⁾ suggests that dietary profile has

an effect on head circumference growth. That study was conducted with groups of Turkish children on exclusive breastfeeding, fed on formula or on mixed feeding during their first 6 months of life and found that, at the end of the sixth month, head circumference measurements were significantly larger for exclusively breastfed children than those on other types of feeding.



Graph 1 a-b – 5th, 50th and 95th percentiles for head circumference of 86 boys, by age, compared with WHO/2006 standard (A) and NCHS/1977 reference (B)



Graph 2 a-b - 5th, 50th and 95th percentiles for head circumference of 95 girls, by age, compared with WHO/2006 standard (A) and NCHS/1977 reference (B)

Irrespective of the fact that the children in this study met their expected growth velocity, it is necessary to bear in mind that this study has certain methodological limitations. The most important is, undoubtedly, the selection bias resulting from the non-probabilistic, sample recruited at a service that is a breastfeeding center of excellence, which means that, however encouraging the results, they cannot be generalized externally. Another limitation is the encouragement that mothers were given to take part in the study and to follow the exclusive breastfeeding recommendations, with positive implications for the study outcome.

It is concluded that boys exhibited greater head circumference growth than girls. The head circumference of these children grew in line with the 50th percentile of the WHO/2006 standard and of the NCHS/1977 reference. These results support the claim that breastmilk as the only source of nutrition for the first 6 months of life promotes adequate head

circumference growth. It is important to adopt measures to support nursing mothers to guarantee exclusive breastfeeding for the first 6 months of life. Children's growth should be fully monitored from birth onwards, longitudinally and using a reference standard for the purposes of evaluation.

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Reference

1. Spyrides MH, Struchiner CJ, Barbosa MT, Kac G. Efeito da duração da amamentação predominante no crescimento infantil: um estudo prospectivo com modelos não lineares de efeitos mistos. *J Pediatr (Rio J)* 2008; 84:237-43.
2. Fewtrell MS, Morgan JB, Duggan C, Gunnlaugsson G, Hibberd PL, Lucas A *et al*. Optimal duration of exclusive breastfeeding: what is the evidence to support current recommendations? *Am J Clin Nutr* 2007;85:635-8.
3. Donma MM, Donma O. The influence of feeding patterns on head circumference among Turkish infants during the first 6 months of life. *Brain Dev* 1997;19:393-7.
4. DeMyer W. Small, large, or abnormally shaped head. In: Maria BL, editor. *Current management in child neurology*. 3th ed. London: BC Decker; 2005. p. 338-41.
5. Bartholomeusz HH, Courchesne E, Karns CM. Relationship between head circumference and brain volume in healthy normal toddlers, children, and adults. *Neuropediatrics* 2002;33:239-41.
6. Viana MR, Alves CL, Alvim CG, Junqueira HS, Goulart LM, Dias LS *et al*. Atenção à saúde da criança. Belo Horizonte: SAS/DNAS; 2004.
7. Clandinin MT, Jumpson J, Suh M. Relationships between fatty acid accretion, membrane composition, and biologic functions. *J Pediatr* 1994;125:S25-32.
8. Zeferino AM, Barros-Filho AA, Bettiol H, Barbieri MA. Acompanhamento do crescimento. *J Pediatr (Rio J)* 2003;79 (Suppl 1):S23-32.
9. Sociedade de Pediatria do Rio Grande do Sul. A atenção à saúde da criança de zero a cinco anos de idade. Rio Grande do Sul: SPRS; 2004.
10. Soares NT. Um novo referencial antropométrico de crescimento: significados e implicações. *Rev Nutr* 2003;16:93-104.
11. World Health Organization. An evaluation of infant growth: the use and interpretation of anthropometry. *Bull World Health Organ* 1995;73:165-74.
12. de Onis M, Garza C, Habicht JP. Time for a new growth reference. *Pediatrics* 1997;100:e8.
13. de Onis M, Garza C, Victora CG, Onyango AW, Frongillo EA, Martinez J. The WHO Multicentre Growth Reference Study: planning, study design, and methodology. *Food Nutr Bull* 2004;25 (Suppl 1):S15-26.
14. Araújo CL. Avaliação nutricional de crianças. In: Kag G, Sichieri R, Gigante DP. *Epidemiologia nutricional*. Rio de Janeiro: Fiocruz/Atheneu; 2007. p. 49-781.
15. Lozano de la Torre MJ. Nuevo patrón de crecimiento infantil de la Organización Mundial de la Salud basado en lactantes amamantados. *An Pediatr (Barc)* 2007;66:177-83.
16. Victora CG, Araújo CL, Onis M [homepage on the Internet]. Uma nova curva de crescimento para o século XXI [cited 2007 mar 20]. Available from: http://189.28.128.100/nutricao/docs/geral/nova_curva_cresc_sec_xxi.pdf
17. Giugliani ER. O aleitamento materno na prática clínica. *J Pediatr (Rio J)* 2000;76 (Suppl 3):S238-52.
18. Diaz S, Herrerros C, Aravena R, Casado ME, Reyes MV, Schiappacasse V. Breast-feeding duration and growth of fully breast-fed infants in a poor urban Chilean population. *Am J Clin Nutr* 1995;62:371-6.
19. Otaigbe BE, Alikor EA, Nkanginieme KE. Growth pattern of exclusively breastfed infants in the first six months of life: a study of babies delivered at the University of Port Harcourt Teaching Hospital, Rivers State, Nigeria. *Niger J Med* 2005;14:137-45.
20. Agostoni C, Grandi F, Gianni ML, Silano M, Torcoletti M, Giovannini M *et al*. Growth patterns of breast fed and formula fed infants in the first 12 months of life: an Italian study. *Arch Dis Child* 1999;81:395-9.
21. Gökçay G, Turan JM, Partalci A, Neyzi O. Growth of infants during the first year of life according to feeding regimen in the first 4 months. *J Trop Pediatr* 2003;49:6-12.
22. World Health Organization [homepage on the Internet]. The WHO child growth standards [cited 2007 Jun 8]. Available from: <http://www.who.int/childgrowth/standards/en>
23. Hamill PV, Drizd TA, Johnson CL, Reed RB, Roche AF. NCHS growth curves for children birth-18 years. United States. *Vital Health Stat* 11 1977;1-74.
24. Macchiaverni LM, Barros-Filho AA. Perímetro cefálico: por que medir sempre. *Medicina, Ribeirão Preto* 1998;31:595-609.
25. Brasil - Ministério da Saúde. Secretaria de Políticas da Saúde. Saúde da criança: acompanhamento do crescimento e desenvolvimento infantil. Normas e manuais técnicos. Brasília: Ministério da Saúde, 2002.
26. García-Alix A, Sáenz-de Pipaón M, Martínez M, Salas-Hernández S, Quero J. Utilidad del perímetro cefálico en el recién nacido para anticipar problemas en el neurodesarrollo. *Rev Neurol* 2004;39:548-54.
27. Fujimura M, Seryu JI. Velocity of head growth during the perinatal period. *Arch Dis Child* 1977;52:105-12.
28. Singh M. Nutrition, brain and environment: how to have smarter babies? *Indian Pediatr* 2003;40:213-20.
29. Lucas A, Morley R, Cole TJ, Lister G, Leeson-Payne C. Breast milk and subsequent intelligence quotient in children born preterm. *Lancet* 1992;339:261-4.