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Review article

Nutrition and cognitive function

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Abstract

The work of the Medical Research Council Dunn Nutrition Unit, Cambridge, on the influence of early diet on the development of preterm infants is reviewed. Then further consideration is given to the implication of the findings. Malnutrition during a sensitive period may result in disease in adult life, and studies strongly suggest the development of the brain and retina can be affected. This may be due to the lack of essential fatty acids, and will particularly involve premature babies born at a time when cell membrane development is especially vulnerable. These findings must sometimes be viewed with caution, as genetic and environmental influences can be paramount. There are many reasons to favour breast feeding, rather than giving formula feeds, including improved cognition and visual function. For example breast milk contains docosahexaenoic acid and arachidonic acid, essential for normal brain development, and often absent or in short supply in formula feeds. Although the advantages in developmental status may be due, in part anyhow, to factors such as the mother's ability and education, and to the child being given greater opportunities, the evident importance of the composition of human breast milk cannot be denied. Formula feeds do contain a higher nutrient value than breast milk, which can result in improved height and weight of infants fed in this way; if it is necessary to use them the challenge for future research is to improve their composition. Although this may be of more importance for premature babies, term babies can also be affected; this has both medical and social implications. © 1997 Elsevier Science B.V.

Keywords: Malnutrition; Sensitive period; Brain development; Breast milk; Formula feed

1. Introduction

There seems to be no doubt that a number of conditions causing ill-heath in adult life may have their origins very early in life, even before birth. These include hypertension, coronary heart disease, and non-insulin dependent diabetes. It now seems likely that not only health but development may be affected in this way. One factor may be the composition of breast milk.

2. Preterm infants

The researches of Lucas, Morley and their colleagues, have been reported in a number of papers. A large multicentre study on the short- and long-term clinical and developmental outcome of infants randomised to different diets was started in 1984 [1]. There were 194, ill and well, preterm infants with a mean gestational age of 31 weeks, and a mean birth weight of 1364 g examined in two trials. One compared banked breast milk with a preterm formula, and the other compared these diets as supplements to maternal milk. The effect of the diet on the number of days taken to regain birth weight, and subsequent gains in weight, length, and head circumference were observed. Infants fed banked breast milk, and weighing less than 1200 g, took an additional 3 weeks to reach 2000 g compared to those fed on the preterm formula. A significant influence on body proportions was seen in the relation between weight, length, and head circumference. A smaller difference in growth patterns was seen in the supplement trial. By the time the infants, of birth weights from 1200 to 1849 g fed on banked breast milk, reached 2000 g, and infants of birth weight below 1200 g fed on either banked breast milk, or on maternal milk supplemented as necessary with banked breast milk, they fulfilled the criteria of failure to thrive, with weight less than 2 SD below the mean for age. Only infants fed on the preterm formula as their sole diet maintained their birth centile when discharged from hospital.

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The better growth of those infants fed with the preterm formula may well be due to the increased protein intake, and that of other factors, in this formula.

Another study (1988) [2] investigated factors which influenced mothers in their choice to provide milk for their premature infants. A well educated, married, primiparous mother aged 20 or over, who delivered a baby boy by caesarean section was nearly a 1000 times more likely to choose to express her milk to provide for a premature infant than a mother who was poorly educated, single, multiparous, aged under 20, and delivering a female infant vaginally. Evidence suggested that hospital staff had little influence on the mother's choice. Cigarette smoking by the mother, especially in the second trimester, gave a negative correlation with the choice to provide breast milk. These findings have important implications for the design of non-randomised trials of feeding regimes for premature infants, such as comparing maternal milk and different formula, as differing results may be due to other factors than the diet.

In a paper published in the same year Morley et al. [3] studied the association between a mother's choice to provide breast milk and her baby's developmental status at 18 months post term in 771 low birth weight infants babies whose mothers chose to provide milk had an 8-point advantage in mean Bayley mental development index over infants of mothers who chose not to. A 4.3 point advantage remained after adjusting for demographic and perinatal factors, and similar findings resulted from a different questionnaire based test. Whether this advantage relates to perinatal factors or to the beneficial effects of human milk on brain development, it does have important implications for the nutritional management of premature babies. Pollock [4] advised caution in attributing the improved development to the breast feeding when it may be due to the positive health behaviour of the mother, and also the intention to breast feed may not last very long. Although there may have been failures in adjusting for the advantage, particularly in relating this to the mother's decision to provide milk as an indication of good parenting, there is a definite possibility that fresh maternal milk contains factors which promote brain maturation in a period of rapid preterm growth. Also it has to be stressed that developmental scores at 18 months have limited predictive value for future mental ability.

However, the intelligence quotients in the same children were assessed at the age of 7.5–8 years old [5]. Three hundred children were assessed on an abbreviated version of the WISC, and those who had consumed mother's milk in the early weeks of life had a higher IQ than those who received none. Over half a standard deviation in IQ remained after adjustment for differences between groups in mother's education and social class. This advantage was associated with being fed mother's milk by tube rather than with breast feeding. Although the effects of parenting skills and genetic potentials could not be excluded, it does seem to confirm the benefit of human milk on neurodevelopment, and that human milk contains factors that compensate for its poor nutritional value, the latter accounting for the slower growth of infants fed in this way, rather than with formula feeds. Human milk certainly contains substances such as long-chain fatty acids, present in large amounts in the retina and brain, as well as hormones, biologically active peptides, and trophic factors which may influence brain growth.

Data from the prospective study published in 1989 [6] involved 502 low birth weight infants assigned randomly, for a median of 30 days, to receive a preterm formula or unfortified donor breast milk as sole diets, or as supplements to their mother's expressed milk. Surviving infants were assessed at 9 months after their expected date of delivery without knowledge of their feeding regimen. The mean developmental quotient was 0.25 SD lower in those fed banked donor breast milk rather than the preterm formula. However among infants fed their mother's expressed milk the disadvantage of receiving banked milk, compared with the preterm formula as a supplement, was greater when the latter was over half the total intake, and approached 5 points, representing 0.5 SD for the developmental quotient. Infants fed donor breast milk were at a particular disadvantage following foetal growth retardation, when the developmental quotient was 5.3 points lower. It is suggested that the diet used for low birth weight babies, over a brief but perhaps critical postnatal period, has developmental consequences that persist into infancy; those who are small for gestational age being especially vulnerable to suboptimal postnatal nutrition. The fact that donor breast milk, given for such a short period in early life, results in a developmental disadvantage at the age of 9 months may well be related to its lower nutritional value compared to the preterm formula, and in particular would not prove adequate for catch-up growth. This could operate through a dietary influence on head and brain growth. On the other hand, the earlier discharge from hospital could have influenced the mother's behaviour towards the child, and the effect of this on development.

The effect of early diet on development was confirmed, in a two centre trial, when 424 preterm infants were randomly assigned a term formula or a nutrient-enriched preterm formula as sole diets, or as supplements to the mother's own expressed milk, for a median of 4 weeks postnatally. The 377 survivors were then assessed at the age of 18 months post term [7]. Those previously fed a preterm, rather than a term formula had major developmental advantages, more marked in motor than mental functions, and especially in small for gestational age infants and in males. Moderate developmental impairment, particularly motor impairment, was considerably commoner in the group fed the term formula; infants fed the preterm formula also had a small benefit in the social maturity quotient. When infants received the trial diets as breast milk supplements the effects were smaller. These results can be linked to the preterm formula containing

nearly 40% more protein and 18% more energy than the standard formula; the differences between the micronutrient and mineral contents were even greater.

In 1994 Lucas et al. [8] published a strictly randomised prospective trial in the three other centres; other studies on the influence of breast milk on later neurodevelopment being non-randomised were potentially confounded by social and demographic differences between groups given breast milk or other feeds. In this trial Bayley psychomotor and mental development indices were assessed at 18 months post-term in survivors of 502 preterm infants assigned to receive, during their early weeks, mature donor breast milk or a preterm formula. These diets were compared as sole enteral feeds or as supplements to the mother's expressed breast milk. No difference in outcome at 18 months were seen between the two groups despite the lower nutrient content of the donor milk compared to the preterm formula and to the estimated needs of the preterm infants. These results are in contrast to the previous study [7]. It is shown that infants from that study fed solely on standard formula, and not a preterm formula, had significantly lower developmental scores at 18 months than those fed on donor breast milk in this report, although the standard formula had a higher nutrient content than the donor milk. So that feeding with the latter had advantages for later development that may have offset any adverse effects due to its low nutrient content for preterm infants. As these advantages were not confounded by the social and educational biases usually associated with the mother's choice to breast feed, the results definitely support the view that breast milk promotes neurodevelopment. Preliminary data from a 7.5–8-year assessment of these children suggests that some of the dietary effects on development are persisting well into childhood [5,9].

3. Brain development

The influence of events in early life could effect development in several ways. It could result from damage to parts of the body, or by altering a somatic structure due to a stimulus or insult during a critical period, or by the insult to a physiological process at this period resulting in long-term consequences for function [10]. It may be better to refer to this critical or vulnerable period as a sensitive period, as although the brain is indeed liable to disruption and damage at this time, it is also one of opportunity to reach its full potential [11]. This has been shown to occur in animals, for example malnutrition during the main spurt of brain growth can result in a life-long failure to acquire certain skills [12]. Also when considering the possible causes of specific learning disorders in childhood it is suggested that these may result from intracerebral connection being destroyed, or never developing in early life from various causes, or never being used [13]. It is surprising how short these periods can be, in animals anyhow. It is a sobering thought that most neurones have formed, and begun to migrate by 22 weeks of gestation, and that in the second half of pregnancy there is an amazing proliferation of axons and dendrites; also that at birth the brain weighs about 350 g, and during the first year of life increases to about 1100 g [14]. Peeling and Smart [15], after reviewing the literature agree that the growth of the brain is less affected by undernutrition than the rest of the body, but that undernutrition depresses the growth rate of various processes within the brain to the same extent. Also it does appear that myelin synthesis is especially sensitive to undernutrition, but this may be due to fewer fibres being myelinated.

Hoeffer and Hardy in 1929 [16] studied the later development of 383 school children, aged 7–13, grouped according to the length of the period of exclusive breast feeding. Compared to breast fed infants, those artificially fed were mostly inferior physically and mentally. The former, when breast fed from 4 to 9 months, were definitely superior to other groups, but after 9 months developed physically at a normal rate but mental development was poor.

This may indicate that breast milk alone, over a certain age, may lack essential ingredients. However, as will now be discussed and has already been shown, in the case of infants at an early age, and if born prematurely, breast milk can contain chemicals lacking in formula feeds which are necessary for normal brain development. The brain is 60% structural lipid; and universally uses arachidonic acid and docosahexaenoic acid, deposited in large amounts in the non-myelin membranes of the developing nervous system, and essential for growth, function, and integrity [17]. Both acids are components of human milk, and lack of them may be harmful to early brain development, especially in low birth weight and premature babies. They are most likely to have been born to mothers inadequately nourished, and may well be born with deficits of these acids. As the effects may be permanent it is obviously vital to protect their status, and ensure optimum conditions for the development of membrane-rich systems such as the nervous and vascular systems. Small for dates, and to a lesser extent, premature babies can be considered to suffer from malnutrition; and this can be due, for example, to defects of placental development, and maternal malnutrition. In the case of the latter it seems that maternal nutrition before conception is more important than nutrition during the second half of pregnancy, when it is too late to affect the most sensitive period of foetal cell division [18]. Also the premature baby is born at a time when cell membrane development is unprepared for the conditions of the extra-uterine environment, and is likely to be affected by feeding regimes which do not replace the nutrients supplied by the placenta.

Uauy et al. concluded that the dietary source of fatty acids can have a profound effect on brain [19] and visual [20] functional development, and that available evidence

suggests that premature infants require docosahexaenoic acid for optimum growth and development. Carlson et al. [21] have confirmed the need for this fatty acid among premature babies if visual and mental functions are to develop normally, and require it to be added to their diet as they are unable to form it in sufficient quantity from alpha-linolenic acid if it is provided by soy oil-based formula products [22].

Also it has been found that, apart from socio-economic cases of starvation, conditions such as congenital hypertrophic pyloric stenosis can have significant effects. Fifty children, aged 5–14 years old, who had had this condition were compared with 44 siblings and 50 controls. Learning ability was negatively correlated with the severity of the starvation. Short-term memory and attention were particularly affected [23].

Lozoff et al. [24] found that children who had iron deficiency in infancy are at risk of long-lasting developmental disadvantage compared with those with normal iron intake. It may be that other nutrients are deficient, or the home environment may be different. The latter was allowed for in this study, but the possibility that the affected children were under stimulated or received a different type of care cannot be excluded.

On the other hand Martyn et al. [25] found no strong association between impaired foetal growth and mental performance in later life, suggesting that foetal growth is less important than genetic factors and environmental influences during postnatal life in determining adult cognitive performance, and that adaptations made by the foetus in response to conditions that retard its growth seem to be largely successful in maintaining brain development. It may no longer be feared that malnutrition during a sensitive period will produce irreversible brain damage leading to severe handicap as there is evidence that most brain structures recover over time. However there may be permanent alterations in the hippocampus and cerebellum, and also in brain neural receptor function. The latter may indicate that the kinds of behaviour and cognitive functions impaired by malnutrition may be more related to emotional responses to stressful events, than to cognitive deficits per se [26].

4. Breast feeding

There are many reasons for favouring breast feeding, such as protection against infection, and avoidance of hypocalcaemia and narcotising enterocolitis, allergic diseases, anaemia, and vitamin deficiencies [27]. It may be equally important that breast milk provides a ready synthesised supply of docosahexaenoic acid, a major component of membrane phospholipids, and of arachidonic acid which can replace the former if there is dietary deficiency of polyunsaturated fatty acids; many infant formulas contain little or none of these substances. Breast-fed infants have significantly greater concentrations of docosahexaenoic acid in their cerebral cortex phospholipids than infants fed on formulas, and as demonstrated in the above investigations, the former are at an advantage in their intellectual development [28]. Various studies reviewed by Smart [29] provided evidence that there was an association between early diet and behavioural development in man, but how lasting the effects were remains open to doubt. Motor development seems to be much more affected than mental development, and the effects of social and environmental influences have to be taken into account. The Standing Committee of the British Paediatric Association concluded that especially in low birth weight infants breast milk, apart from other advantages, was of benefit to cognitive functions [30].

There have been a number of studies on the effects of infant feeding, on specific and general development [31]. Broad [32] assessed 134 boys and girls, and found that there was a distinct relationship between breast feeding and clarity of speech in the male, and breast feeding was associated with improved tonal quality in both sexes, but more marked in the male. It seems that babies who are artificially fed, compared with those entirely breast fed, may not achieve the same successful standard of adjustment to life when assessed at school age; but there may be a number of different influences at work, apart from the different diet [33].

It is understandable that any factor in breast milk, essential for development, would be particularly so in preterm infants, born at a time of rapid brain growth and maturation [9]. Also docosahexaenoic acid can be important in retinal development. It has been shown that healthy preterm and full-term infants on breast milk compared with formula, and examined at 57 weeks postconception had better visual evoked potentials and forced-choice preferential-looking acuity, and that full-term infants at 3 months had better stereo acuity and matching ability [34]. There seems to be no doubt that this is due to the content of essential fatty acids in breast milk [35]. However when it comes to assessing the nutritional benefits of breast milk, and the length of time an infant is breast fed, a degree of caution must be exercised. The advantages in developmental status may be due, in part anyhow, to factors such as the mother's ability and education, and to the children being given greater opportunities [36].

In one study of breast fed and bottle fed children it was found that later in life the former gained higher scores on intelligence tests. Special attention was paid to the method of feeding in infancy in a setting where breast feeding was not linked with socio-economic advantage. Although those adults who were exclusively breast fed did have a slightly higher IQ score than those fed in other ways this difference did not persist after adjustment for other factors in early life, such as the use of a dummy in infancy, the number of older siblings, the father's occupational class, and the mother's age at the birth of the child being studied. Of

these factors the most powerful predictor of IQ was the use of a dummy. There are several possible explanations for this; babies willing to accept a dummy may be slightly less intelligent, those who do may receive less stimulation, those preoccupied with sucking a dummy may be more placid and unwilling to focus on other stimuli, or its use may indicate a home where a child's intellectual potential receives less encouragement and the mother had poorer child-rearing skills [37]. However this study has been criticised on the grounds of selection of the subjects studied, the possibility that the use of the dummy may of itself reduce breast feeding, the effect of social class, and the level of the parent's IQ [38,39].

5. Conclusion

More studies have been carried out on preterm, than term infants, and the former are more vulnerable to lack of nutrients in view of the stage of development reached by their nervous systems. The total essential fatty acid requirements for premature infants should be set, at least, at 4–5% of total energy, and the supply of linoleic acid should be 0.5–0.7 g/kg daily, and formulas for these infants should provide 35–75 mg of long-chain polyunsaturated fatty acids per kilogram of body weight per day as docosahexaenoic acid [40]. However it has been shown that term infants who are breast fed can also be affected. Porter [41] found that such children had better stereo acuity and matching ability at 3 years than those who were formula fed, and this advantage probably translates into quicker learning and easier performance of complex motor tasks.

Human milk leads to more effective utilisation of proteins, fat, minerals, and trace elements. It also has other advantages such as providing passive immunologic protection and active immunostimulation. The disadvantages are the volume required to provide the energy and protein needs of very low birth weight babies, and the risks of infections from banked milk. Formula feeds do contain a higher nutrient value than breast milk, which no doubt accounts for the better increase in height and weight in early infancy of babies fed on the former. However when it comes to visual and cognitive functions, follow-up studies show that breast feeding is best, and the challenge now is to further improve formulas when these have to be given, particularly for preterm infants, in order that their amino acid, essential fatty acid and carbohydrate composition are nearer that of human milk so that the building stones are available for normal development [42,43]. Further research is also needed on problems like the actions of phytoestrogens present in soy based infant formula in the human body.

The possibility that even temporary food shortages can produce adverse outcomes in developed as well as developing countries cannot be ignored [44]. The positive evidence certainly favours this, and therefore intervention, whether this is nutritional, social, or educational must surely be given the highest priority.

References

[1] Lucas A, Gore SM, Cole TJ et al. Multicentre trial on feeding low birth weight infants: effects of diet on early growth. Arch. Dis. Child. 1984; 59: 722–730.

[2] Lucas A, Cole TJ, Morley R et al. Factors associated with maternal choice to provide breast milk for low birth weight infants. Arch. Dis. Child. 1988; 63: 48–52.

[3] Morley R, Cole TJ, Powell R, Lucas A. Mother's choice to provide breast milk and developmental outcome. Arch. Dis. Child. 1988; 63: 1382–1385.

[4] Pollock JI. Mother's choice to provide breast milk and developmental outcome. Arch. Dis. Child. 1989; 64: 763–764.

[5] Lucas A, Morley R, Cole TJ, Lister G, Leeson-Payne C. Breast milk and subsequent intelligence quotient in children born preterm. Lancet 1992; 339: 261–264.

[6] Lucas A, Morley R, Cole TJ et al. Early diet in preterm babies. Arch. Dis. Child. 1989; 64: 1570–1578.

[7] Lucas A, Morley R, Cole TJ et al. Early diet in preterm babies and developmental status at 18 months. Lancet 1990; 335: 1477–1481.

[8] Lucas A, Morley R, Cole TJ, Gore SM. A randomised multicentre study of human milk versus formula and later development in preterm infants. Arch. Dis. Child. 1994; 70: F141–F146.

[9] Morley R, Lucas A. The influence of early diet on outcome in preterm infants. In: Davies DP, editor. Nutrition in Child Health. London: Royal College of Physicians of London, 1995: 67–75.

[10] Lucas A. Role of nutritional programming in determining adult morbidity. Arch. Dis. Child. 1994; 11: 288–290.

[11] Smart JL. Critical periods in brain development. In: The Childhood Environment and Adult Disease (Ciba Foundation Symposium 156). Chichester: Wiley, 1991: 109–128.

[12] Dobbing J. Undernutrition and the developing brain. The relevance of animal models to the human problem. Am. J. Dis. Child. 1970; 120: 411–415.

[13] Gordon N. Neurological Problems in Childhood. Oxford: Butterworth-Heinemann, 1993.

[14] Cockburn F. Breast feeding and the infant human brain. In: Davies DP, editor. Nutrition in Child Health. London: Royal College of Physicians of London, 1995: 3–12.

[15] Peeling AN, Smart JL. Review of literature showing that undernutrition affects the growth rate of all processes in the brain to the same extent. Metab. Brain Dis. 1994; 9: 33–42.

[16] Hoefer C, Hardy MC. Late development of breast fed and artificially fed infants. J. Am. Med. Assoc. 1929; 92: 615–619.

[17] Innes SM. Fatty acid requirements of the newborn. Can. J. Physiol. Pharmacol. 1994; 72: 1483–1492.

[18] Crawford MA. The role of essential fatty acids in neural development: implications for perinatal nutrition. Am. J. Clin. Nutr. 1993; 57 (Suppl.): 7035–7105.

[19] Uauy R, Birch E, Birch D, Peirano P. Visual and brain function measurements in studies of n-3 fatty acid requirements of infants. J. Pediatr. 1992; 120: 5168–5180.

[20] Uauy R, Birch DG, Birch EE, Tyson JE, Hoffran DR. Effect of dietary omega-3 fatty acids on retinal function of very-low-birth-weight neonates. Pediatr. Res. 1990; 28: 485–492.

[21] Carlson SE, Werkman SH, Peeples JM, Wilson WM. Long-chain fatty acids and early visual and cognitive development of preterm infants. Eur. J. Clin. Nutr. 1994; 48 (Suppl. 2): 527–530.

[22] Uauy-Degach R, Birch EE, Birch DG, Hoffman DR. Significance of ω3 fatty acids for retinal and brain development of preterm and term infants. World Rev. Nutr. Diet 1994; 75: 52–62.

[23] Klein PS, Forbes GB, Nader PR. Effects of starvation in infancy (pyloric stenosis) on subsequent learning abilities. J. Pediatr. 1975; 87: 8–15.
[24] Lozoff B, Jimenez E, Wolf AW. Long-term developmental outcome of infants with iron deficiency. N. Engl. J. Med. 1991; 325: 687–694.
[25] Martyn CN, Gale CR, Sayer AA, Fall C. Growth in utero and cognitive function in adult life: follow-up study of people born between 1920 and 1943. Br. Med. J. 1996; 312: 1393–1396.
[26] Levitsky DA, Strupp BJ. Malnutrition and the brain: changing concepts, changing concerns. J. Nutr. 1995; 125 (Suppl. 8): 2212s–2220s.
[27] Taylor B. Breast versus bottle feeding. N. Z. Med. J. 1977; 85: 235–243.
[28] Morley R, Lucas A. Influence of early diet on outcome in preterm infants. Acta Paediatr. 1994; (Suppl. 405): 123–126.
[29] Smart JL. Symposium on behavioural consequences of undernutrition. Proc. Nutr. Soc. 1993; 52: 189–199.
[30] Standing Committee on Nutrition of the British Paediatric Association. Is breast feeding beneficial in the UK. Arch. Dis. Child. 1994; 71: 376–380.
[31] Rodgers B. Feeding in infancy and later ability and attainment: a longitudinal study. Dev. Med. Child. Neurol. 1978; 20: 421–426.
[32] Broad FE. The effects of infant feeding in speech quality. N. Z. Med. J. 1972; 76: 28–31.
[33] Rogerson BCF, Rogerson CH. Feeding in infancy and subsequent psychological difficulties. J. Ment. Sci. 1939; 85: 1163–1182.
[34] Birch E, Birch D, Hoffman D, Hale L, Everett M, Uauy R. Breastfeeding and optimal visual development. J. Pediatr. Ophthalmol. Strabismus 1993; 30: 33–38.
[35] Makrides M, Simmer K, Goggin M, Gibson A. Erythrocyte docosahexaenoic acid correlates with the visual response of healthy, term infants. Pediatr. Res. 1993; 33: 425–427.
[36] Silva PA, Buckfield P, Spears GF. Some maternal and child developmental characteristics associated with breast feeding: report from the Dunedin Multidisciplinary Child Development Study. Austr. Paediatr. J. 1978; 14: 265–268.
[37] Gale CR, Martyn CN. Breast feeding, dummy use, and adult intelligence. Lancet 1996; 347: 1072–1075.
[38] Cockburn F, Tappin D, Stone D. Breastfeeding, dummy use, and adult intelligence. Lancet 1996; 347: 1765–1766.
[39] Lucas A, Morley R. Breastfeeding, dummy use, and adult intelligence. Lancet 1996; 325: 1765.
[40] Uauy R, Hoffman DR. Essential fatty acid requirements for normal eye and brain development. Sem. Perinatol. 1991; 15: 449–455.
[41] Porter CA. Breastfeeding, dummy use, and adult intelligence. Lancet 1996; 347: 1766.
[42] Heine W. Is mother's milk the most suitable food for very low birth weight infants. Early Hum. Dev. 1992; 29: 345–350.
[43] Uauy-Dagach R, Nena P. Nutritional role of omega-3 fatty acids during the perinatal period. Clin. Perinatol. 1995; 22: 157–175.
[44] Brown JL, Sherman LP. Policy implications of new scientific knowledge. J. Nutr. 1995; 125 (Suppl. 8): 2281s–2284s.