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Review Article

Nutrition and Children's Intelligence Quotient (IQ): Review

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Abstract

Child nutrition especially during the early years is crucial for the development of the whole body and the mentally in specific. Mechanism by which the nutrition can affect the Intelligence is still questionable. Aim of this review was to identify the latest studies done in the last 5 years regarding nutrition and IQ of the children. Systematic review was done using Pubmed , searching engine, with words like nutrition, food, diet and IQ of the children. We include only orginal studies done in the last 5 years (from 2008-2013). Nineteen original articles were selected in 4 areas acoording to the outcomes of the studies, they are nutiritonal status, diet, breastfeeding and milk formaula. As a conclusion, Despite the long period since the studies on association between nutrition and intelligence began in last decade, this issue still under huge contraversay. There is no doubt about the importance of nutrition during the early years of child development, but is nutrient deficinces can lead to low intelligence.

Keywords: Nutrition; Intelligence Quitiont IQ; Child

Introduction

Maintaining brain function is very important for cognitive development and also behavirоual performance. The most crucial factor is the supply of metabolic fuel to the brain in the form of glucose. This is maintained by complicated mechanisms involving several feedback loops and hormones to ensure that glycaemia is regulated and available at appropriate levels at all times. Mental activity should be protected from fluctuations in nutritional status from one meal to another.

Several studies done previously concluded that poor nutritional status could affect brain function and impact on cognition and behaviour development. According to Bellisle [1] if appropriate correction of nutrient deficiencies done it can lead to measurable improvement in cognition and even in situations of good nutritional status, the brain can be very sensitive to short-term fluctuation of glucose availability.

The relationship between poor health, nutrition and school achievement is well documented. Low anthropometric measurements (height for age, weight for height and head circumference) have been associated with poor school achievements [2-8]. In fact, in several of the studies the association remained significant, even after controlling for confounders such as socioeconomic factors. Iron-deficiency anaemia, missing breakfast and helminthic infections have also been reported to affect school performance [9-12].

Poor school performance may not be direct result of poor nutritional and health status, but may reflect multi-factorial issues such as poverty and under-nutrition. According to Zalilah et al. [13] malnutrition hinders cognitive development and is one of the contributing factors to generally poor school performance among children from low socio-economic communities. In addition, malnutrition can affect age of enrolment in school, concentration in class, attendance, and infection rates [14-16].

Previous studies done all over the world shows that treating nutritional and health conditions of school children can improve their academic performance. For example, some school food programmes have shown dramatic effects on attendance and school acheivments [14]. In Benin, children in schools provided food services scored significantly higher in tests than those in schools without food services [18].

The mechanism, by which nutrition can affect cognitive development, as Greenwood and Craig [19] stated, "There are at least three important ways in which diet may affect neurochemistry. First, the ingestion of food affects the availability of the precursors required for the synthesis of neurotransmitters. Second, food serves as the source of vitamins and minerals that are essential co-factors for the enzymes that synthesize neurotransmitters. Third, dietary fats alter the composition of the nerve cell membrane and myelin sheath, and that, in turn, influences neuronal function" .

Aim of this review was to identify the latest studies done in the last 5 years regarding the relationship between nutrition and Intelligence Quotient of the children.

Methods

Comprehensive literature review

Original articles were screened during the period from 1st January 2008 to 31st December 2013, using the following source PubMed. Several keywords were used, including 'Nutrition', 'Diet', 'IQ', 'Gognitive', 'Children', 'Asscoiation'.

Selection criteria

Only orginal articles that specifically described "nutiriton and IQ from 2008 to 2013" were included in our study. Those review papers or describing nutrition alone as well as those that occurred before the year 2008 were excluded.

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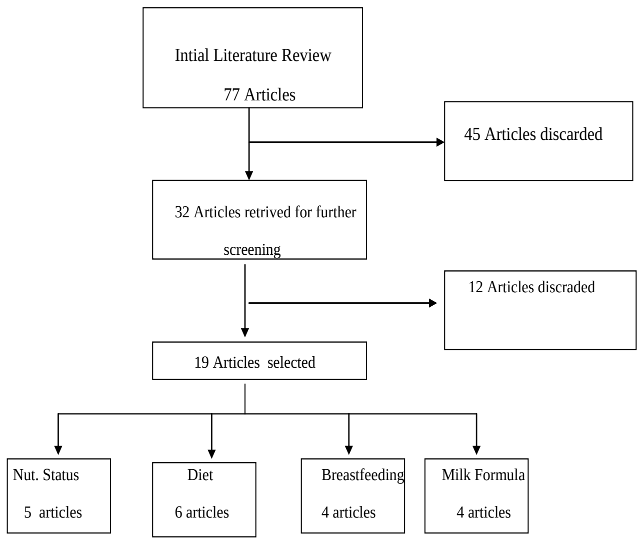

Figure 1: Flow chart of article selection process.

Findings

Nineteen papers met our inclusion criteria , we will devide our findings to 4 areas acoording to the outcomes of the studies, they are nutiritonal status, diet, breastfeeding and milk formaula.

Nutritional status

Six papers out of twenty discussed the relationship between children nutritional status and their intelligence quotient. Nutritional status is very important indecator of growth development especially among children. Wieght and height can be compared with international cut-off points of children with same age and sex such as CDC data or WHO growth refrences.

According to Taki et al. [20] the possible mechanism on how nutirtional status can affect the cognetive development that gray and white matter volume of the brain may mediate the correlation between body height and intelligence in healthy children. In addittion, the association between gray and white matter volume, height, and IQ may be at least partially explained by the effect of insulin-like growth factor-1 and growth hormones.

Sandajaja et al. [21] concluded in theri study that undernourishment and non-verbal IQ are significantly associated among children aged 6 to 12 years old in their study conducted in South East Asia region (SEANUTS). They found that children with low Weight-for-Age Z score were 3.5 times more likely to have a non-verbal IQ less than 89. The chance of having a non-verbal IQ less than 89 was also doubled with low BMI-for-Age Z score and Height-for-Age Z score.

Another study done by Smithers et al. [22] found that faster gains in weight or head circumference in the 4 weeks after birth may contribute to children's IQ, but reverse causality cannot be excluded. Physical growth in early childhood is associated with IQ at 9 years of age. The strongest and most consistent relationships were with height at birth, early infancy, and late infancy. As for the weight, only early infancy gain was consistently related to IQ [23].

A study done by Okumura et al. [24] found that full and verbal IQ score was significantly lower in undernourished infants compared to those well nourished. Among undernourished infants, those with persistent dysmature patterns tended to have lower full and performance IQ compared to those without persistent dysmature patterns.

Diet

The type of diet taht child consumed can affect his cognitive development. The possible mechanism of how the diet can effect the cognitive development was explained by Taki et al. [25], in their study they found that breakfast type can affects brain gray and white matter volumes and cognitive function in healthy children. they argued that although several factors may have cofounded their outcomes, one possible mechanism explaining the difference between the bread and the rice may be the difference in the Glycemic Index (GI) of these two materials. Foods with a low GI are associated with less blood-glucose fluctuation than are those with a high GI. A higher Glycemic index score of diatery patterns according to Golley et al. [26] was positively associated with total, verbal, and performance IQ scores at 8 years of age .

Also the type of food consumed at specific age was associated with IQ scores acoording to Smithers et al. [27] as they found that dietary patterns from 6 to 24 months old may have a small but persistent effect on IQ scores at age 8 years. A Breastfeeding pattern at 6 months and home-made contemporary patterns at 15 and 24 months were associated with 1 to 2 points higher IQ score. A Home-made traditional pattern such as cooked vegetables at 6 months was positively associated with higher IQ scores, but there was no association with similar patterns at 15 or 24 months.

The other important type of diets is fortified food that showed persistent effect on cognitive development of young children which could persist until 6 years of age. Acoording to a study done by Chen et al. [28] Full IQ scores of children in the group using the fortified formula was 3.1 and 4.5 points higher than that in secong group with non fortified formula and in control group respectively. Verbal IQ scores of children in the group using the fortified formula was 2.1 and 5 points higher than that in in secong group with non fortified formula and control group respectively. Performance IQ was 2.5 and 3.1 points higher than that in in secong group with non fortified formula and control group respectively [28].

Dietary patterns in early life may have some effect on cognitive development. children whose diet in infancy was characterised by high consumption of fruit, vegetables and home-prepared foods had higher full-scale and verbal IQ and better memory performance at age 4 years [29].

Lastely, according to Isaacs et al. [30] if there was any diatry intervention during pregnancy especially between 26 and 34 weeks of gestation it can affect IQ scores at age 16 years.

Breast feeding

Several studies have focused on the association between breast feeding duration and cognitive development, without any deffinative conclusion. Some previous studies reported that exclusive breastfeed children can score higher on IQ tests compared to those children with milk formula feeding.

Table 1: Summery of the selected articles.

No	Auhtor	Year	Sample size	Age	IQ test	Design	Main findings
1	Sandjaja et al. [21]	2013	6746	6-12Y	Raven's Progressive Matrices test or Test of Non-Verbal Intelligence, third edition (TONI-3)	Cross-sectional	Children with low weight-for-age Z score have 3.5 times more chance to get non-verbal IQ less than 89, and it was doubled with low BMI-for-age Z score and low height-for-age Z score.
2	Golley et al. [26]	2013	4429	7-8 Y		Cross-sectional	Diatery patterns of children was positively associated with total, verbal, and performance IQ scores at 8 years of age
3	Willatts et al. [36]	2013	235	6Y	Wechsler Preschool and Primary Scale of Intelligence–Revised (WPPSI-R)	Randomized Clinical Trial (RCT)	IQ scores of children who were fed a formula containing either LC-PUFAs or no LC-PUFAs did not differ at age 6 years old.
4	Smithers et al. [22]	2013	25,831	6.5 Y	Wechsler Abbreviated Scales of Intelligence and the Strengths and Difficulties Questionnaire (SDQ)	Cross sectional	Faster gains in weight or head circumference in the 4 weeks after birth may contribute to children's IQ in teh future.
5	De Jong et al. [37]	2012	474	9 Y	Developmental Neuropsychological Assessment (NEPSY)	Randomized Clinical Trial (RCT)	No consistent beneficial effect of LCPUFA formula supplementation on cognitive development in term-born infants was found.
6	Smithers et al. [27]	2012	7,097	8Y	Wechsler Intelligence Scale for Children	Cross-sectional	Dietary patterns from 6 to 24 months may have a small but persistent effect on IQ at 8 years age.
7	Tozzi et al. [31]	2012	1403	10-12Y	Wechsler Intelligence Scale for Children (WISC-R)		Breastfed healthy children may perform better on neuropsychological tests in the language domain at 10 to 12 years of age.
8	Pongcharoen et al. [23]	2012	560	9Y	Wechsler Intelligence Scale for Children (WISC), third edition	Cross sectional	Physical growth in early infancy is associated with IQ at 9 years of age.
9	Iacovou & Sevilla[32]	2013	10,419	8 Y	Academic attainment was measured via Standard Attainment Test (SATs) scores	Cohort	Scheduldded Feeding to infants is associated with higher levels of maternal wellbeing, but with poorer cognitive and academic performances for children.
10	Isaacs et al. [35]	2011	107	10Y	The Wechsler Abbreviated Scale of Intelligence	RCT followup	Long-chain polyunsaturated fatty acids (LCPUFAs) are a key factor in the cognitive benefits of breast milk
11	Taki et al. [20]	2012	160	5-18Y		Cross sectional	Gray and white matter volume may mediate the correlation between body height and intelligence in healthy children.
12	Jedrychowski et al. [33]	2012	468	Preschool	psychometric tests	Cohort	The breastfeeding-related IQ gain observed already at the age of 1 year was sustained through out preschool age.
13	Taki et al. [25]	2010	290	5.6 to 18.4 years	Wechsler adult intelligence scale (WAIS; version 3) and the Japanese version of the Wechsler intelligence scale for children (WISC version 3)	Cross sectional	Breakfast staple type affects brain gray and white matter volumes and cognitive function in healthy children.
14	Chen et al. [28]	2010	1478	2Y		Randomized Clinical Trial (RCT)	Fortification of food showed persistent effect on intelligence development of young children which could persist to 6 years of age.
15	Holme et al. [34]	2010	982	9Y	British Ability Scales and Quick NeurologicaScreening Test (QNST)	Secondary Data analysis	Breastfeeding was not associated with any crude IQ advantage or difference in neurological soft signs in children at 9 years.
16	Gale et al. [38]	2010	241	4Y	Wechsler Pre-School and Primary Scale of Intelligence	Cohort	Children who were fed DHA-fortified formula had full-scale and verbal IQ scores that were respectively 5.62 and 7.02 points higher than children fed unfortified formula.
17	Okumura et al. [24]	2010	30	6 and 9 Y		Follow up	Full and verbal IQ was significantly lower in infants with undernutrition than those with normal nutrition
18	Isaacs et al. [30]	2009	95	8 and 16Y	Wechsler Intelligence Scale for Children-Revised (WISC-R)	Randomized Clinical Trial (RCT)	A brief period of dietary intervention after preterm birth, principally between 26 and 34 weeks of gestation, affected IQ at age 16 years.
19	Gale et al. [29]	2009	241	4Y	Wechsler Pre-School and Primary Scale of Intelligence (3rd edn)	Cross sectional	Dietary patterns in early life may have some effect on cognitive development.

Healthy children who breastfed may perform better on neuropsychological tests in the language domain at 10 to 12 years of age according to a study done by Tozzi et al. [31] they concluded the effect of breast milk on neuropsychological performance in healthy children may have a limited clinical relevance and may be confounded by parental educational level [31].

On the other hand, a study done by Iacovou & Sevilla [32] argued taht scheduled feeding to babies can be associated with higher levels of maternal wellbeing, but poorer cognitive and academic performance for children later in life. After controlling for confounders, schedule-fed babies performed around 17% of a standard deviation below demand-fed babies in tests at all ages, and 4 points lower in IQ tests at age 8 years.

Jedrychowski et al. [33] suggested that breastfeeding-related IQ gain observed at the age of one was sustained through preschool age, and the difference in terms of IQ scores between breastfed children and the control group held constant over the whole preschool period.

Some other studies found no association between breastfeeding with any crude IQ advantage or difference in neurological soft signs in children at 9 years old. Holme et al. [34] concluded that the highest IQ score associated with breastfeeding children is accounted for coufounders such as maternal IQ and socio-economic characteristics.

Milk formula

Some studies showed that long-chain polyunsaturated fatty acids (LCPUFAs) are a key factor in the cognitive benefits of breast milk [35]. Intelligence Quotient scores of children who were fed a formula containing either LC-PUFAs or no LC-PUFAs did not differ at age 6 years old. However, children who received LC-PUFAs were faster at processing information compared with children who received unsupplemented formula. This variation in the dietary supply of LC-PUFAs in the first few months of life may have long-term effects for cognitive development in later childhood [36].

There is no consistent beneficial effect of LCPUFA formula supplementation on cognitive development in full term babies according to De Jong et al. [37] and their study confirmed that breastfeeding is associated with better cognition later in life.

According to Gale et al. [38] differences in children's intelligence according to type of milk fed in infancy may be due more to confounding by maternal or family characteristics than to the amount of long-chain polyunsaturated fatty acids they receive in milk. children who were fed DHA-fortified formula had higher full-scale and verbal IQ scores than children fed unfortified formula.

Conclusion

Despite the long period since the studies on association between nutrition and intelligence began in last decade, this issue still under huge contraversay. There is no doubt about the importance of nutrition during the early years of child development, but is nutrient deficinces can lead to low intelligence. as we know growth of the children depened on nutrition and also the environement where he or she grows up in. In the case of the intellegence there is a third factor that paly a very important role which is genetics inhereted from parents. More studies needed to explore the effects of nutrition on intellegence development with the controlling of genetics factors.

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