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Nutritional status and performance in test of verbal and non-verbal intelligence in 6 year old children

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Abstract

The relationship between nutritional status and intellectual capacity in 6-year-old children was investigated in 83 subjects of medium-high socio-economic status, without any apparent risk of malnutrition and normal or high intellectual capacity. Nutritional status was evaluated by measuring food consumption, anthropometrical measurements and biochemical indicators (iron status, red cell folate and total plasma homocysteine concentration (tHcy)). IQ was evaluated using the WPPSI test. The relationship between nutritional status and IQ was investigated by multiple linear regression analysis adjusting for socio-demographic variables and sex. There was a significant and positive relationship between iron intake and both total and non-verbal IQ. This was also the case for folate intake and both total and verbal IQ. The fact that these observations were made in children from a developed country, in which their energy and education requirements are met, suggests that their cognitive development may benefit from specific preventive nutritional interventions with these nutrients.

Keywords: Nutritional status; Iron; Folate; Performance; Verbal intelligence; Non-verbal intelligence; Children

1. Introduction

A number of studies have investigated the effect of nutritional status on intellectual capacity in recent decades (Wurtman & Wurtman, 1977; Naeye, Diener, Dellinger, & Blanc, 1969). However, one of the main problems in establishing a causal association between nutritional status and intelligence is that global malnutrition is generally associated with other conditions of environmental deprivation and biological risk which act as confounding factors in the analysis. These factors have been controlled in some studies. The effect of nutritional status on intelligence quotient (IQ) in young South-Africans was studied adjusting for maternal socio-economic level and head circumference (Stoch, Smythe, Moodie, & Bradshaw, 1982). Other studies have controlled genetic factors, in estimating the difference in IQ in brothers who had different nutritional status during lactation (Birch, Pineiro, Alcalde, Toca, & Cravioto, 1971) or between monozygotic twins of different birth weight (Lynn, 1993). The differences in IQ observed in these studies ranged from 2 to 9 points. Since the groups were defined on the basis of prenatal markers, this suggests that prenatal nutritional deficiencies may have permanent effects on the brain.

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Apart from the prenatal period, the role of adequate nutrition is crucial during the first 5 years of life for brain development (Lynn, 1993).

Positive effects of nutritional supplementation on intelligence or achievement have been reported in lactants, school children and adolescents as well as pregnant mothers in both developed or developing countries (Kugelmass, Poull, & Samuel, 1944; Lynn & Harland, 1998; Pollitt, Gorman, Engle, Rivera, & Martorell, 1995; Schoenthaler, Bier Young, Nicholas, & Jansenns, 2000). However, a recent review (Benton, 2001) concluded that the beneficial effect of supplementation on IQ was more specifically observed in non-verbal measurements of the same. This author also states that children who previously had deficient diets respond the best to micronutrient supplementation. Southon et al. (1994) also observed that supplementing 13–14-year-old adolescents with minerals and vitamins for 16 weeks did not improve their intellectual achievement.

Associations between body development, mainly head circumference and height and results of cognitive tests have also been observed in well-nourished school populations (Bayley, 1956; Ivanovic, Forno, Castro, & Ivanonic, 2000; Mussen, Langer, & Covington, 1969). The association between head size and IQ have also been tested by nuclear magnetic resonance (Plaza et al., 2001).

Recent studies have considered that the principal reasons for the increase in secular trends in mean intelligence test scores in developed countries are improved nutritional status and health care (Flynn, 1987). This improvement in intelligence, known as the Flynn effect, has been observed mainly at lower intelligence levels and is less evident at higher levels (Colom, Lluis-Font, & Andres-Pueyo, 2005; Lynn & Hampson, 1986).

The secular increases in height have also been used as an indicator of nutritional status and have been correlated with increased intelligence. However in the last Norwegian cohorts studied in the XX century, such increases were no longer evident. Thus the Flynn effect may no longer be present in populations which have experienced a global improvement in life over recent decades (Sundet, Barlaug, & Torjussen, 2004).

The belief that the effect of nutrition on intelligence is no longer an issue in adequately nourished populations may explain why few studies investigate the causal effect of nutritional status on intelligence in developed countries.

Relatively frequent specific nutrient deficiencies occur in these populations with an apparently good global nutritional status (Arija, Salas-Salvado, Fernandez, Cuco, & Marti-Henneberg, 1996; Salas, Galan, Arija, & Marti-Hennegerg, 1990). Some of these deficiencies such as iodine, iron and folate are all important for brain development and emerging cognitive function (Bryan, Osendarp, Hughes, & Cravioto, 2004). Another micronutrient essential for brain cell function is pyridoxine which has a role in the biosynthesis of neurotransmitters fundamental for memory and learning and in myelinization and amino acid metabolism (Guilarte, 1993). Also zinc is essential for DNA and protein synthesis based on evidence from experimental animal models (Wasantwisut, 1997). Pollitt, Mueller, and Leibel (1982) reported that indicators of iron status (hemoglobin, serum iron and transferrin saturation), anthropometrical measurements (weight/height) and maternal education level were associated with IQ in healthy children. A relationship between plasma folate concentration and memory deterioration in adults has been suggested (Riedel & Jorissen, 1998). Kleinman et al. (2002) observed in 97 American school children that those with an intake with 2 nutrients below 50% of the Recommended Daily Allowance (RDA) had significantly worse grades in reading, mathematics, history, geography and science compared with children whose nutrient RDAs were met.

Our hypothesis was that iron and folate nutritional status would be associated with childhood IQ. The aim of this study was to investigate the relationship between nutritional status (energy and nutritional intake, anthropometrical measurements and biochemcial indicators) and IQ (total, verbal and non-verbal) in a sample of 6-year-old children in a developed country, with no apparent risk of malnutrition, medium to high IQ and a medium-high socio-economic level.

2. Material and methods

2.1. Subjects

85 6-year-old subjects participated. 2 children with IQ below 79 were excluded. This sample consisted of 83 subjects (43 boys and 40 girls) from a Mediterranean City (Reus, Spain) with a population of 100,000. The socio-economic level of our sample is higher than the mean socio-economic level in Spain. These children formed part of a longitudinal study in which their mothers, volunteers planning on becoming pregnant immediately were studied from preconception throughout pregnancy. The nutritional status of the children was evaluated at birth, 6 months and 6 years of age. The exclusion criteria for the participating mothers were: