

Iron Deficiency and Psychomotor Development of Infants in Libreville (Gabon): Iron Deficiency does not Explain Everything

Eliane Kuissi Kamgaing, Steeve Minto'o*, Julienne Minko, Larissa Midili, Edmée Mintsa, Samuel Mbadinga, Jean Koko and Simon Ategb

Department of Pediatrics, Faculty of Medicine, University of Health Sciences, Libreville, Gabon

***Corresponding Author:** Steeve Minto'o, Assistant, Department of Pediatrics, Faculty of Medicine, University of Health Sciences, Libreville, Gabon.

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Abstract

Aim: To establish a link between iron deficiency and impaired psychomotor development, and to identify factors correlated with that impaired development.

Methods: A prospective study, including apparently healthy infants aged 6 to 23 months, who were assessed for markers of iron status and psychometric tests with Brunet-Lézine Revised scale.

Results: We included 138 infants, 71 boys (51.4%) for 67 girls (48.6%), 72% were iron deficient. The overall development quotient (ODQ) of the sample was 94 ± 8.2 , the ODQ of iron-deficient children was 92.9 ± 6.8 vs. 99.7 ± 8.5 for non-iron deficient ($p < 0,001$). The relative risk of having bad results in case of iron deficiency vs non-iron deficiency was $RR = 1.8$ (IC 95% [1.2 - 2.6]). The relative risk of having bad results in psychomotor tests in case of a mother without university degree vs mother with university degree was $RR = 2.8$ (IC 95% [2.2 - 3.1]).

Conclusion: ID is strongly correlated with poor psychometric test results, but does not in itself justify poor infant psychomotor development in our setting.

Keywords: Iron Deficiency; Psychomotor Development; Infant; Gabon

Abbreviations

BLR: Brunet-Lezine Revised Scale; CDQ: Oculomotor Coordination Quotient; ID: Iron Deficiency; IDA: Iron Deficiency Anemia; LDQ: Language Development Quotient; ODQ: Overall Development Quotient; PDQ: Postural Development Quotient; SDQ: Sociability Development Quotient; RR: Relative Risk

Introduction

Iron deficiency anemia (IDA) and iron deficiency (ID) have been linked to increase childhood morbidity and to impair cognitive development and school performance [1]. Studies attest that myelination of the human brain takes place in early life. Thus determining the critical phase of the enhancement of cognitive ability, while enzymes using iron are involved in the myelination process [2,3]. Developing countries, therefore, face a real underhanded threat, the consequences of which affect adults by altering their physical skills, and also future generations by spoiling a proper brain development of those who will take care of the present generation, in the future [1,4].

Several surveys have shown the link between iron deficiency and psychomotor acquisition in developed countries, but little attention has been given to the African child, who is already suffering from malnutrition in a global way [4]. We did not find any data about iron deficiency and psychomotor development in infant in Central or Western Africa.

Our main objective was to establish a relation between ID and poor psychomotor development in pre-school children in an urban African setting and then to identify the other factors correlated with that impaired development.

Materials and Methods

We conducted a prospective cross sectional survey, from January to May 2015, which included 157 apparently healthy infants, aged from 6 months to 23 months. They were recruited from health centers during immunization sessions, or in kindergartens, away from an episode of illness.

Selection of subjects

The children included were not carriers of a known chronic disease such as HIV/AIDS or sickle cell anemia. We did not include children aged more than 23 months at the enrolment, born preterm; children who had received a transfusion for any reason; children who had already benefited from iron supplementation or any iron fortification program; and children who had a fever at the acceptance.

Conduct of the survey

We received the families twice, in the morning, in a kindergarten classroom. During the semi-directed interview, we recorded socio-economic data of the family of the children. The data were: age of the mother, her level of study and professional activity; social categorization of the family according to the criteria of the Ministry of Plan of Gabon (rich, middle rich, middle poor and poor); the rank of the child in the siblings; number of children kept in the home where the child lived. After the interview, the child was accompanied into an adjoining room to undergo psychomotor development tests with psychologists from the Department of Psychology of the Omar Bongo University of Libreville (National University of Gabon), specialized in child development; they passed the Revised Brunet-Lezine Scale (BLR). That scale assesses the four development sectors for children aged four months to two years: postural development, oculomotor coordination, language, socialization with a development quotient for each sector, The overall development quotient is quickly calculated in the case of homogeneity. Results are given in overall development quotient (ODQ), the postural quotient (PDQ), oculomotor coordination quotient (CDQ), language quotient (LDQ) and sociability quotient (SDQ). The BLR scale is one of the scales validated and commonly used in this department, to evaluate infants for more than ten years. That scale is also worldwide used even in particular situations [5]. After a second BLR test, early in the next morning, on fasting, we proceeded to take only up to 3 mL of the venous blood from the children. We determined by micro methods the iron status of the children with serum ferritin dosage, unsaturated iron binding capacity (UIBC), serum iron (Fe), and Complete blood cells count (CBC). CBC was performed on Beckman Coulter STKS analyzer, Fe, and UIBC on Abbott's ALCYON 300i, serum ferritin on Abbott's IM-X.

Definition of cases

We considered as "iron deficient" any subject with a serum ferritin < 12 ng/mL; or UIBC < 10%; Or a CMH < 25pg associated with a red cell width (Rdw) > 15%; or MCV < 80 fL. We considered as "healthy" all the subjects who were not anemic and showed no signs of ID. We classified as "other," subjects with anemia without signs of ID.

Constitution of the sample

Figure 1 shows the flow of the subjects who followed the process of our investigation.

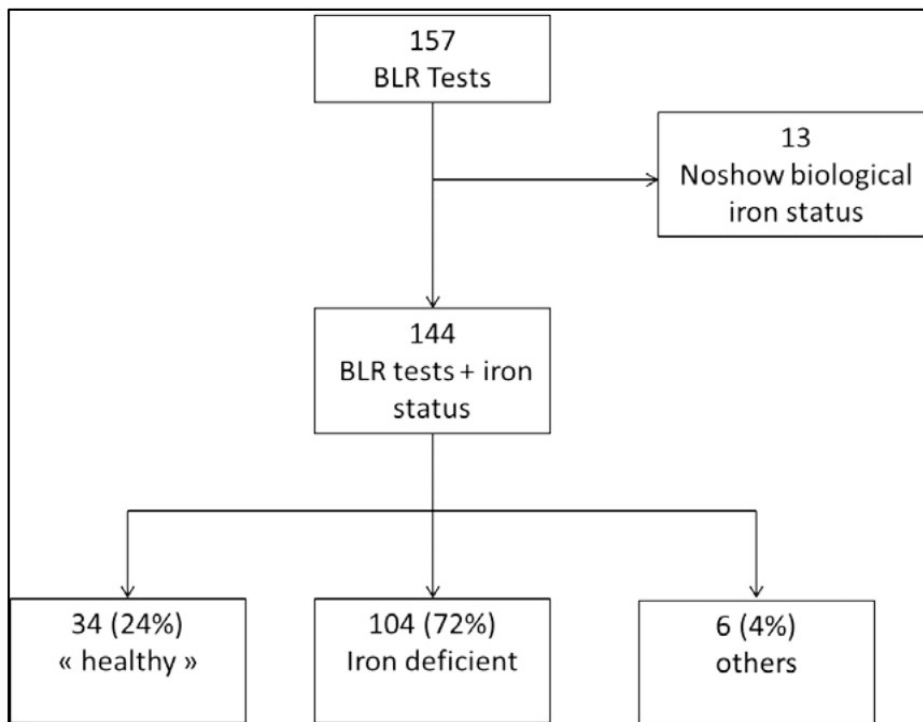


Figure 1: Flowchart of our subjects.

Ethical considerations and parental agreement

We received the authorization of the Ministry of Public Health before start our inquiry. Parents had to sign the informed consent form to allow the participation of children in the investigation.

Data Management

The data were managed on Epi Info 7, and analyzed on SPSS 20. Chi-square test was used to assess differences in categorical data between groups. The analysis of Student’s t-test was used for comparisons of means. Relative risk (RR) was used to compare a risk factor between two groups. A p-value < 0.05 was considered significant.

Results and Discussion

Results

A total of 138 children formed the sample of our analysis. The average age of the children was 16.2 ± 4.6 months, with 71 boys (51.4%) for 67 girls (48.6%), a sex ratio of 1.06. They came from families that had an average of 4.3 ± 3.2 children at home, and on average were the 3rd of siblings.

The families of the children in the sample were classified as “rich” for 5.1% (n = 7), “middle rich” for 37.6% (n = 52), “middle poor” for 48.5% (n = 67), and “poor” for 8.7% (n = 12). Children’s mothers, or mother’s surrogates were without remunerative activity in 63% (n = 87) and 37% (n = 51) had a gainful activity. In terms of mother’s education, 30% (n = 41) had a university degree, 61% (n = 84) had stopped high school, and 9% (n=13) had primary education.

Table 1 shows the mean scores of the children in the BLR test sample. In the “middle poor” category (N = 67), 51 (76.1%) were ID, 14 (20.9%) were healthy, and 2 (3%) were classified as others. We compared the scores of the infants in that socioeconomic class, table 2 shows the comparison of results at BLR tests between iron deficient v. healthy children from the “middle poor” class. The relative risks (RRs) of having a poor score on the BLR psychomotor development assessment tests were calculated between different groups and summarized in table 3.

	All (n=138)	Healthy (n = 34)	ID (n = 104)	*p
ODQ	94 ± 8.2	99.7 ± 8.5	92.9 ± 6.8	0.009
PDQ	102 ± 7.6	106.2 ± 6.9	100.4 ± 6.7	0.02
CDQ	94,1 ± 6.1	99.1 ± 4.9	91,9 ± 8.4	0.01
LDQ	92,6 ± 9.4	96.9 ± 9.3	92 ± 8.1	0.001
SDQ	91 ± 9.9	96.6 ± 6.2	88.2 ± 9.2	0.003

Table 1: Means of scores at BLR tests.

*value according to Student’ t-test comparing “healthy” children and ID children

	Healthy (n= 14)	ID (n= 51)	*p
ODQ	99.1 ± 3.5	92.9 ± 9.7	< 0.001
PDQ	106.1 ± 5.4	100.4 ± 12.7	< 0.001
CDQ	96.3 ± 3.4	91,9 ± 8.4	0.001
LDQ	94.9 ± 6.3	92 ± 11.1	NS
SDQ	96.6 ± 6.2	88.2 ± 9.2	NS

Table 2: Means of scores at BLR tests of iron deficient vs. healthy children from “middle rich” families.

*value according to Student’ t-test comparing “healthy” children and ID children

	RR	IC 95%
ID vs. Healthy	1.8	[1.2 - 2.6]
A mother without university degree vs. mother with univ. Degree	2.8	[2.2 - 3.1]
Middle rich and rich families vs. middle poor and poor families	1.06	[0.7 - 1.3]
Unemployed mother vs. working mother	1.4	[0.8 - 1.9]
rank > 2 in siblings vs rank ≤ 2	1.2	[0.7 - 1.6]
Siblings ≥ 4 children vs siblings < 4 children	1.3	[0.9 - 1.6]

Table 3: Relative risk (RR) to obtain a bad score at ODQ of BLR test.

Discussion

For 20 years, studies have highlighted the importance of the period of the 1000 first days of the child on the adult it will be. This period goes from conception to 2 years old. During this period, the child’s brain acquires 80% of its final mass, the motor, cognitive and language brain functions are put in place during this period. These functions are dependent on nutrition and its environment [3,6]. The psychomotor developments of the African child and its anthropological distinctiveness have been described since the 1950s [7]. The growing of the African child is caught between the cultural particularities of his parents and the modernity accelerated by globalization [8].

Sample characters

The size of our final sample was 138 children aged 6 to 23 months. This number may seem low in comparison with similar surveys conducted in Asia, including that of Xu K., *et al.* which succeeded in collecting 326 IDA children of the same age group, as well as Rothman., *et al.*'s survey on 750 infants in South Africa [9,10]. However, our number is similar to the standard surveys conducted in Europe, like the one of Dommergues., *et al.* which studied 147 children of the same age [11]. Our sample is correct, considering the population of our country, as well as the ethical difficulties to make blood samples on apparently healthy children.

We could have done a case-control study with as many iron deficiency as healthy children. That would have given more statistical power to our investigation. But the high prevalence of iron deficiency at this age would have forced us to take at least 3 times more children. This, in our context would have been a problem on ethics especially and also on financing.

Our sample was not randomly selected but on a voluntary basis. This sample shows characteristics close to the general population of Gabon for the same age. Namely: a sex ratio close to 1, an average sib ship size equal to 4, a low rate of mothers having studied at university (30%) [12,13]. Nevertheless, the "poor" family classification was only found in about 9% of cases, but the various reports show that 20% of Gabon's population lives below the poverty line [13,14]. This difference can be explained by a response bias, our interview taking place in front of several people, the parents may have overestimated the reality, thus giving a score that led to classify them in families "middle poor," rather than "poor".

The sideropenic children in our sample accounted for 72%, which is consistent with all the surveys on the subject in Gabon, which give between 72% and 80% of iron deficiency in children of this age group in Gabon [12,15]. This last result adds another point to the representativeness of our sample.

Overall test results

Developmental tests of the entire sample show result consistent with a standard population. The average of the PQD of our sample (more specific of the motor development) is higher than that of the Western populations which made it possible to calibrate the BLR test [16]. The children in our sample have an advance on the motor compared to the Western populations. This motor precocity of the African infant could be explained by two facts: the cultural habits of Africans, and the number of people living with children. In Africa, parents practice daily massages and other muscular stimulation at an early age, with the aim of rapidly promoting sitting and then walking [7,8]. A large number of people at home (more than four children in our survey), promotes the passage of the child between several hands during the day. These facts help the socialization and the muscular activity of the infant. This finding of motor early maturity of the African child was already that of Dean since 1950, but nuanced since then by Gerber or Dasen. These authors report that this evident advance in the first 12 months gradually faded in the second year, the causes mentioned were the weaning and the modification of cultural habits in contact with globalization [7,17].

Iron deficiency and BLR test results

Iron-deficient children had lower scores in all areas than non-deficient children. All surveys are unanimous on this subject. We note, particularly that in the motor component domains (PQD, CQD), the average of the iron deficient children scores of our sample was lower than those of the healthy children, but remained standard compared to the calibration population [16]. The comparison of psychomotor tests results among the group of children in the "middle poor" socioeconomic category confirms that the domain of gross motor and fine motor skills are impacted in our context, however the results showed no significant difference in social and language skills, even though the scores in LDQ and SDQ were below the references. Xu K., *et al.* had the same findings than our study : IDA group had significantly lower scores in Gesell general development quotient, gross motor, fine motor and also adaptive behavior than the control group ($P < 0.05$) [9]. In their old but standard study, Dommergues., *et al.* showed that ID is associated with low scores in all the domains, but especially in behavior and language [11]. Rothman., *et al.* in South Africa didn't find a significant difference in gross motor skills, fine motor skills and

parent rating, between ID and non-ID children. Differences were observed according to birthweight and length for age z-score at 6 months old [10].

The absence of difference in LDQ and SDQ could be explained by the psychosocial stimulation mentioned earlier. This stimulation of the familiar environment could play a protective role against psychomotor defects in ID. The number of persons at home in Gabon is bigger than in France or in China, our findings show a mean of 4 children at home against the single child policy in China [12,13].

We didn't divide the groups according to the depth of anemia. This was due to number of subjects of our study. Many other study tend to demonstrate that the deeper the deficiency is the worse the effects on psychomotor development are. Tofail, *et al.* found that children with iron deficiency anemia had worse responses to Bayley-scale tests than children anemic without iron deficiency [18]. Pala E., *et al.* noticed that the rate of abnormal Denver II tests were higher in IDA children (63,7%) than in ID children (21,6%), highlighting a link between the severity of iron deficiency and the psychomotor performances of the children [19]. Rothman., *et al.* in a study about 750 children didn't set a difference in developmental scores between anemic and non-anemic children [10]. Rioux., *et al.* in Canada didn't find any relationship between mother's iron or DHA status and cognitive's performance, even though there is an evident link between maternal iron status and neonate iron status [20].

The psychomotor impairment in iron deficiency is justified physiologically by the involvement of ferroproteins in the myelination processes occurring during infancy, most of the behavioral damage is often put forward [3,18,21]. Tofail, *et al.* noted that this psychomotor impairment persisted after psychosocial stimulation and concluded that iron-deficient children needed more attention for their leveling, which also included iron supplementation. Questions about other nutritional deficiencies remain, as iron deficiency is rarely isolated in Africa, regardless of the standard of living [1]. Some authors believe that iron deficiency is emphasized because it has a higher prevalence, but the role of other essential nutrients must not be overlooked [1,3,21].

Other related factors

Iron deficiency alone was a factor in poor psychomotor development, with a relative risk of 1.8 in deficient children compared to non-deficient children. Our survey found that the mother's level of education was the factor that had the most significant impact on the psychomotor development of the child: the more educated the mother, the better the child's test scores. These results are comparable to Forns., *et al.* results in a cohort study who observed a crude association between maternal intelligence and cognitive development in children at 14 months when the mother had a manual occupation, but the difference disappeared when the mothers had a high level of education [22]. Xu., *et al.* who established that mother's lack of knowledge about iron deficiency is associated to Gesell test low scores [9]. This result can be explained on the one hand by the possibility of having a better-paid job when the mother is trained, and thus of acting positively on the quality of the child's food intake. On the other hand, mothers with a university education level would be more aware of the interest and the need to stimulate areas of infant development. Our results are different from those of Rothman., *et al.* found no relation between caregiver educational level and psychomotor development at 6 months [10]. There was a difference only due to birth weight, stunting and breastfeeding. However, our finding on the unique role of the mother's characteristics in the psychomotor and psycho-emotional development of the child has been noted for decades to the present day [21,22].

Conclusion

Iron deficiency is associated with poor psychomotor development in our context, especially on the motor domain of the infant. Our results, supported by other investigations, show that iron deficiency alone does not determine the child's psychomotor development. The level of education of the mother and the global malnutrition appear on the front line. The fight against iron deficiency and its consequences in Africa requires a response that takes into account all these factors.

Conflict of interest

The authors declare no financial interest and no conflict of interest.

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