*Afr J Med med Sci* (1998) 27, 95-99

# The influence of iodine deficiency on the cognitive performance of school children in Saki, South-West Nigeria

***A.C. Ojule and B.O. Osotimehin**
*Department of Chemical Pathology, University College Hospital, Ibadan, Nigeria. *Department of Chemical Pathology, University of Port Harcourt Teaching Hospital, Port Harcourt, Nigeria.*

**Summary**
The influence of inadequate iodine intake on the thyroid status and cognitive performance of school children in Saki, a town within the goitre belt of South-western Nigeria with known environmental iodine deficiency, was assessed. One hundred and ninety-seven (197) study subjects from Saki and seventy (70) appropriately matched control subjects from Moniya, near Ibadan, the Oyo State capital were recruited into the study. The subjects were apparently healthy primary school pupils between the ages of 10 and 14 years and had been resident in the respective locality for at least two (2) years. After establishing the presence of goitre, blood was collected for thyroid function tests by venepuncture from each pupil. The cognitive function tests, Draw-A-Person (DAP) test and the Standard Progressive Matrices (SPM) were administered simultaneously to all the pupils in the class. Urine samples were collected for urinary iodine estimation. The mean urinary iodine concentration was significantly lower in Saki than in Moniya (134.81 ± 69.86 vs 220.00 ± 69.00 ug/L, $P < 0.01$). The total goitre rates (TGR) and the visible goitre rates (VGR) were 15.2% and 1.5% for Saki, and 8.6% and 4.3% for Moniya, respectively. The mean plasma total T4 was significantly lower in Saki pupils (97.55 ± 26.64 nmol/L vs 122.52 ± 26.51 nmol/L $P < 0.05$). The TSH level was higher in Saki pupils than in Moniya pupils (4.72 ± 1.38 mU/L vs 4.26 ± 1.28 mU/L), but the difference was not statistically significant. Scores on intelligence function tests (DAP and SPM) were lower for Saki pupils when compared with Moniya pupils, though the differences were not statistically significant.

These results show that there is a mild but significant iodine deficiency disorder problem in Saki. However, the children in Saki still maintained euthyroidism and the mild degree of iodine deficiency did not seem to have adversely affected their cognitive performance.

**Keywords**: *Iodine deficiency, Endemic goitre, Hypothyroidism, Cretinism, Cognitive function.*

**Résumé**
L'influence de la consomation inadequate d'iode sur le status de la thyroide et la performance congenitive des élève de Saki, Une ville situe dans la ceinture du sud-ouest du Nigeria, et reconnut par son insufisance d'iode environmental a été evalué. Cent quatre-vingt-dix-Sept (197) subjects de Saki et 70 subjects ser vant de controle provenant de Moniya (près d''badan), la capitale de l''tata d'O' avaient été enrolés dans létude. Les sujets étaient apparement en bonne santé et tous élèves de l'ecole primaire agés entre 10 et 14 ans. Ils étaient resisdents des localités choisis pour une periode d'au moins deux ans. A près avoir etablit la presence du goitre, le sang était collecté chez ces patients pour le teste de la fonction de la thyroide.' Les testes de la fonction cogenitire, le Draw-A-Person (DAP) teste, et al Matrice du standard Progressif (SPM) étaient administré simultanement à tous les élèves de la la classe. Les urines étaient aussi collecté pour l'estimation du taux d'iode dan sles urines. La concentration moyenne de l'iode dans les urines était significativement ailble dans les urines à Saki qú à Moniya (134,81 ± 68,86 conre 220 ± 69,00 Ug/L, $P < 0,01$). Le taux total de Goitre (TGR) et le taux de goitre visible (VGR) était de 15,2% et 1,5% pour Saki et 8,6% et 4,3% pour Moniya respectivement. La moyenne totale du $T_4$ dans le plasma avait été significativement faible chez les élèves de Saki (97,555 ± 26,64 nmol/L contre 122,52 ± 26,51 nmol/L $P = 0.05$). Le niveaux de TSH avait été plus élevé à Shaki qu'a Moniya (4,72 ± 1.38 MU/L contre 1,28 mU/L), mais la difference n'était pas statistiquement significative. Les scores sur les testes des la fonction de l'intelligence (DAP et SPM) étaient plus faible chez les élèves de Saki l'orsque compaé à ceix de, Moniya, quoique les differences n'étaient pas statistiquement significantive. Ces resultats montrent que il ya un leger mais significative problème d'IDD à Saki. Cependent, les enfants à Saki ont toujours maintenus un euthryroidisme et le leger degréde defience en iode n'a pas semblé auoir un effect devastateur sur leur performances cognitive.

Correspondence: Dr A.C. Ojule, Department of Chemical Pathology, University of Port Harcourt Teaching Hospital, P.M.B 6173, Port Harcourt, Nigeria.

## Introduction

Impairment of nervous system development and function is the most important consequence of iodine deficiency. It has been observed in several iodine deficient environments that, in addition to the few clinically obvious cretins, a large number of individuals suffer from various lesser degrees of impairment of brain function due to hypothyroidism [1]. These include various degrees of impaired mental and motor function among the school children and the general population [1-5]. In fact, stunting of intellectual function in iodine deficient communities has been demonstrated [6]. Studies in school children living in iodine-deficient areas indicate impaired school performance and intelligence quotient (IQ) in comparison with matched groups from non-iodine-deficient areas [2]. Muzzo et al [7] have further demonstrated poorer performance in IQ tests by those children with goitre in comparison to those without goitre in the same area.

Other studies have also demonstrated improvements in school performance and IQ following iodine supplementation [8,9]. It has even been suggested that the extent of these types of "subscretinous" brain damage should be the most important criterion by which one should assess the health and socio-economic significance of iodine deficiency in an environment [1].

These studies highlight the importance of assessment of cognitive function in school children as part of the total assessment of the effects of iodine deficiency in iodine-deficient region. Previous studies in Saki had indicated the presence of significant iodine-deficiency disorder (IDD) problems in this locality [10,11]. Saki is the headquarter of Ifedapo Local Government Area of Oyo State of Nigeria. It lies towards the northern border of the state, close to Kwara State in the North, and the Republic of Benin in the West. It is a distance of about 195 km from Ibadan, the Oyo State capital. The vegetation is Guinea savannah. The topography is hilly and rocky. Saki is semi-urbanised and thickly populated. The population is 230,713 by the 1991 census figures. Saki lies in the extensive endemic goitre belt of South western Nigeria as described by Olurin in 1974 [10]. Apart from the earlier goitre prevalence surveys done by Olurin [10] between 1970 and 1974, no further evaluation of the IDD in this area had been undertaken to our knowledge. We therefore designed this study to assess the nutritional iodine status and the current goitre prevalence rate among school children in Saki. The study further assessed the thyroid status and cognitive performance of these school children, with a view of fully assessing the health and socio economic significance of environmental iodine deficiency in this locality.

## Materials and methods

*Subject*

One hundred and ninety-seven (197) study subjects from Saki and seventy (70) appropriately matched control subjects from Moniya were recruited into the study. Previous studies had adjudged Moniya to be non-iodine-deficient [10,11]. Moniya is the headquarter of Akinyele Local Government Area of Oyo State of Nigeria. Both Saki and Moriya are culturally similar and at about the same level of socio-economic development.

The subjects were apparently healthy primary school pupils in Classes 5 and 6 and between the ages of 10 and 14 years and had been resident in the respective localities for at least two years. Prior informed consent for this study was obtained from the respective Local Governments through their Local Education Authorities and Health Departments, the Parents/Teachers Association of the schools, the school authorities and the pupils.

Cognitive/intellectual function of the pupils was assesed by the use of two different cross-cultural test instruments, namely the Draw-A-Person (DAP) test and the Standard Progressive Matrices (SPM). The DAP test was originally developed by Florence L. Good enough in 1926 for quick assessment of intellectual and developmental maturity of children. This test scores the presence in the drawing of definite parts of the body, their correct number, the correct proportions, spatial relationships of different parts, etc. The DAP test has very high correlation with other intelligence tests such as the Standard Binet Test and Wechsler Intelligence Test and has been standardized for Nigeria [12].

The SPM was developed in Great Britain by JC Raven, in 1938. It was designed to test an individual's intellectual capacity and has been used widely in other cultures throughout the world due to its relatively easy mode of administration and due to the fact that, being non-verbal in nature, it does not penalise subjects mainly on grounds of their inability to read or understand the English Language. The scale consists of 60 matrices items divided into five (A, B, C, D, E) of 12 items each. Each item consists of a design from which a part has been removed. The subject is required to select the missing part from six or eight alternatives provided below each design. Each set consists of matrices of increasing difficulty. While the earlier series require accuracy of visual discrimination, the latter ones involve two dimensional analogies which demand permutation, alternation of patterns and perception of other logical relations for successful solution. Each correct answer scores one mark while wrong answers score nothing.

These test instruments can be used to identify the basic intellectual capacity of an individual student or a group of students. Thus, a comparison of an individual's score with their group mean score or the mean scores of two groups can identify the comparative level of intellectual capacity-average, below average or above average. The subjects were studied in class groups of 30 to 50 pupils. On arrival in each class, the study procedure was explained in English and the local language. The pupils were then called up in turns for physical examination, anthropometric measurements and recording of personal data. For each pupil, a serially numbered sheet of foolscap-sized duplicating paper was provided. On one side of the paper was printed the answer sheet of the SPM test. This side also contained columns for the name, age, sex, weight, height, class and goitre size of the pupils. The other side of the sheet was blank.

Height and weight were assumed and recorded and the neck examined for goitre by palpation. 5.0 ml of blood was then collected by venepuncture into lithium-heparin bottles and the plasma separated and stored at $-20\ ^0C$ for estimation of triiodothyronine (T3), thyroxine (T4) and thyroid stimulating hormone (TSH).

On completion of physical examination and blood sampling, the pupils were asked to turn over the blank sides of their paper for the DAP test. They were instructed to use their pencils to "draw a person as best as they could". There was no time limit. On completion of the DAP test, booklets of the SPM test were distributed to each pupil. Standard instructions for the test were given in both English and the local Yoruba languages and the pupils commenced the test. There was also no time limit as the pupils were encouraged to answer all the questions.

On completion, each pupil submitted their SPM booklet and the answer sheet (with the DAP drawing on the reverse side). All pupils were then encouraged to void urine for urinary iodine estimation.

Plasma total T3 and total T4 and TSH were estimated by radioimmunoassay (RIA) using standard commercial kits from Diagnostic Products Corporation, Los Angeles, California, USA. T3 was assayed by a double antibody method while T4 and TSH were assayed by a solid phase coated tube (Coat-A-Count) method. Urinary iodine was estimated by the acid digestion method of IPCIDD (International Training and Support Programme for the Control of Iodine Deficiency Disorders, Centers for Disease Control, Atlanta, Georgia, U.S.A.), using the arsenious acid/ceric ion/iodine colorimetric reaction.

Goitre was graded according to World Health Organization (WHO) criteria, as endorsed by the International Council for Control of Iodine Deficiency Disorders (ICCIDD) as follows:

Grade 0 = no goitre; Grade 1A = Thyroid gland larger than terminal phalanx of thumb of subject (the gland is palpable but not visible); Grade 1B = Thyroid enlarged, palpable and visible with neck extended; Grade 2 = Thyroid enlarged and visible with neck in normal position; Grade 3 = Thyroid enlarged, visible from 10 metres. The DAP and SPM tests were scored according to standard procedure [12,13].

All results are expressed as mean ± SD (standard deviation). Mean values for study and control subjects were compared by the unpaired Student's t-test using OXSTAT II statistics programme on an IBM compatible Sanyo personal computer. $P < 0.05$ was taken as the level of statistical significance.

**Results**

A total of 197 pupils from Saki and 70 pupils from Moniya were recruited into the study. These total numbers were used to calculate the goitre rates only. For all other parameters, only values for pupils in Primary 6 (95 in Saki and 50 in Moniya) were used in computing the figures. This sub-set of primary 6 pupils was used because it was only in this group that complete data on plasma hormone levels and scores on the intelligence tests were available.

Table 1 summarizes the characteristics of study and control subjects. It shows that both groups were fairly matched in terms of age, height, weight and male/female ratio. However, the Saki pupils were slightly younger than the Moniya pupils (11.48 ± 0.92 Vs 12.50 ± 0.78 years, $P$ 0.05). Table 2 summarizes the thyroid status indices and scores on cognitive function tests for the study and control populations.

**Table 1**: Characteristics of study and control subjects (Mean + SD)

| | Saki n = 197 | Moniya n = 70 |
|---|---|---|
| Male: Female ratio | 1 : 0.8 | 1 : 0.6 |
| Age (years) | 11.48 ± 0.92* | 12.50 ± 0.78 |
| Weight (kg) | 28.60 ± 4.78 | 26.73 ± 3.65 |
| Height (m) | 1.34 ± 0.08 | 1.43 ± 0.57 |

SD = Standard Deviation *$P < 0.05$.

**Table 2**: Indices of iodine deficiency and scores on intelligence tests (Mean ± SD)

| | Saki n = 95 | Moniya n = 50 |
|---|---|---|
| Total goitre rate (TGR) | 15.2% | 8.6% |
| Visible goitre rate (VGR) | 1.5% | 4.3% |
| Triiodothyronine (T3) (nmol/L) | 1.93 ± 0.36 | 1.99 ± 0.43 |
| Thyroxine (T4) (nmol/L) | 97.55 ± 26.64* | 122.52 ± 26.51 |
| Thyroid stimulating hormone (mU/L) | 4.72 ± 1.38 | 4.26 ± 1.28 |
| Mean urinary iodine (ug/L) | 134.81 ± 69.86* | 220.00 ± 69.00 |
| Median urinary iodine (ug/L) | 130.0 | 247.5 |
| SPM score | 13.88 ± 4.39 | 16.41 ± 7.28 |
| DAP score | 0.77 ± 0.15 | 0.74 ± 0.14 |

*$P < 0.05$

(i) *Urinary iodine*

Fifty-two and thirty-four urine samples from pupils in Saki and Moniya, respectively, were assayed for their iodine content. Saki pupils had significantly lower mean urine iodine concentration than Moniya pupils (134.81 ± 69.86 Vs 220.00 ± 69.00 ug/L, $P < 0.05$). Similarly, the median urinary iodine concentration was 130 ug/dl and 247.5 ug/dl for Saki and Moniya, respectively. This confirms relative environmental iodine deficiency in Saki as compared to Moniya.

(ii) *Goitre rates*

The total goitre rate (TGR) was higher in Saki (15.2%) than in Moniya (8.6%). The visible goitre rate (VGR) was however higher in Moniya (4.3%) than in Saki (1.5%). TGR includes Grades 1A, 1B 2 and 3, while VGR includes only Grades 2 and 3.

This result further reflects the relative environmental iodine deficiency in Saki, but the reason(s) for the relatively higher proportion of visible goitres in Moniya is not quite clear from this study and may need further investigation.

(iii) *Thyroid hormone status*

Thyroid hormone (T3, T4 and TSH) levels were similar for both study groups and within our local laboratory reference interval (T3: 1.3-2.8 nmol/L; T4: 57.0-164.0 nmol/L; TSH: 0.3-5.0 mU/L). The mean T3 and T4 levels were relatively higher in Moniya pupils. The differences were not statistically significant except for T4 (122.52 ± 26.51 Vs 97.55 ± 26.64 nmol/l, $P < 0.05$). These results further suggest relative iodine deficiency in Saki, though pupils from both areas remained euthyroid.

(iv) *Intelligence tests*

Scores on both the DAP (0.74 ± 0.14 Vs 0.77 ± 0.15) and SPM (13.88 ± 4.39 Vs 16.41 ± 7.28) were similar for Saki and Moniya. The scores were however relatively higher for Moniya pupils than for Saki pupils, though the differences were not statistically significant. There is no significant correlation between thyroid hormone levels (T3, T4, TSH) and scores on either the SPM or DAP test for both the study and control populations. These results show that there is a mild IDD problem in Saki. However, the children in Saki still maintained euthyroidism and the mild degree of iodine deficiency did not seem to have adversely affected their cognitive performance to any significant degree.

**Discussion**

This study was primarily designed to evaluate the influence of iodine deficiency on the cognitive performance of school children and to assess the current status of thyroid function in school pupils in Saki, a semi-urban town located in an area known to be iodine deficient.

The mean urinary iodine excretion was significantly lower for Saki pupils when compared to pupils from Moniya (134.81 ± 69.87 Vs 220.00 ± 69.00 ug/L, $P < 0.01$). Daily urine iodine excretion and iodine excretion from spot urine samples have been widely accepted as satisfactory indices of iodine intake [14]. Urinary excretion of iodine also reflects the environmental iodine status [15]. Saki can therefore be said to be relatively iodine-deficient when compared with Moniya. Reference values for urinary iodine excretion in Nigeria have not been reported in available literature. The cut-off value suggested by Isichei appears too high (250 ug/L) and needs validation by country-wide studies. The TGR for Saki was 15.2% while that of Moniya was 8.6%. According to WHO/ICCIDD criteria, both areas should be classified as iodine-deficient with mild IDD problems (goitre prevalence between 5 and 20% in school children [17,18]). IDD exists as a public health problem in any area if the total goitre rate in school children exceeds 10% [19-21]. Saki can therefore be said to have a mild but significant IDD problem while the problem in Moniya may also be mild but not yet of public health significance.

The TGR and VGR of 8.6% and 4.3%, respectively, in Moniya were disturbingly high when compared to a goitre rate of 2.0% reported for the same area by Olurin [10] in 1974. However, Olurin used a mixed population of adults and school children, hence our figures may not be directly comparable. It is however, also possible that the higher goitre prevalence rates seen in this study could indicate a worsening situation with regard to the bio-availability of iodine in this community. The mean urinary iodine excretion of 220 ug/L, which is below the 250 ug/L cut-off value suggested by Isichei [16] is a further pointer to this. T3 and TSH levels for both Saki and Moniya pupils were similar except T4 which was significantly lower in the Saki pupils. This finding is corroborated by our observation in the field that pupils from both localities were generally not clinically hypothyroid. This finding is also consistent with the fairly high mean urinary iodine excretion seen in both areas, as compared to other endemic areas with more severe IDD problems where the urinary iodine is usually less than 50 ug/L [22, 23]. This is further reflected by the relatively low goitre rates seen in this study.

The results of the cognitive function test revealed no significant differences between the study and control populations. Lack of significant differences in these intelligence function tests is a further pointer to the mildness of the IDD problem in Saki.

The results also revealed no significant correlation between the individual hormone levels and scores on the intelligence function tests. This emphasizes the fact that the relationship between thyroid hormone levels and cognitive performance is not entire simple, as there are confounding variables such as the level of social deprivation, socio economic status, general nutritional status and genetic factors which are all known to influence performance on intelligence tests [24].

**References**

1. Kochupillai N, Pandar CS. Neonatal chiemical hypothroidism in iodine deficient environments. In: Hetzel BS, Dunn JT, Stanbury JB, eds. The Prevention and Control of Iodine Deficiency Disorders. Amsterdam, Elsevier, 1987; 85-93.
2. Bleichrodt N, Garcia I, Rubio C, Moreeale de Escobar G, Escobal del Rey F. Developmental disorders associated with severe iodine deficiency. In: Hetzel BS, Dunn JT, Stanbury JB, eds. The Prevention and Control of Iodine Deficiency Disorders. Amsterdam, Elsevier, 1987; 65-84.
3. Beleichrodt N, Drenth PJD, Querido A. Effects of iodine deficiency on mental and psychomotor abilities. Am J Phys Anthrop 1980; 53: 55-67.
4. Querido A, Bleichrodt N, Djokomoeljanto R. Thyroid hormones and human mental development. In: Comer AM, Baker RE, Van de Pol NE, Swaab DF, Uylings HBM, eds. Maturation of the Nervous system. Progress in Brain Research. Amsterdam, Elsevier/North-Holland Biomedical, 1978; 337-344.
5. Connolly KJ, Pharaoh POD, Hetzel BS. Fetal iodine deficiency and motor performance during childhood. Lancet 1979; ii: 1149-1151.
6. Boyages SC, Collins JK, Maberly CF, Jupp JJ, Morris JG, Eastman CJ. Iodine deficiency impairs intellectual and neuromotor development in apparently normal person. Med J Aust 1989; 150: 676-679.
7. Muzzo S, Leiva L, Carrasco D. Influence of a moderate iodine deficiency upon intellectual coefficient of school-age children. In: Medeiros-Neto N, Maciel F, halpera J, eds. Iodine deficiency disorders and cogenital hypothyroidism. Ache, Sao Paulo, 1986; 40-45.
8. Fierro-Benitez R, Casar R, Stanbury JB, Rodriques P, Fierro-Renoy F, Estrella E. Long-term effect of correction of iodine deficiency on psychomotor and intellectual development. In: Dunn JT, Pretell EA, Daza G, Vieri E. eds. Towards the eradication of endemic goitre, cretinism and iodine deficiency, PAHO, Washington, 1986; 182-200.
9. Bantista A, Barker PA, Dunn JT, Sanchez M, Kaiser DL. The effects of oral iodized oil on intelligence, thyroid status, and somatic growth in school-age children from an area of endemic goitre. Am J Clin Nutr 1982; 35: 127-134.
10. Olurin EO. The fire of life (The Thyroid Gland). Inaugural Lectures 1974 – 1975, University of Ibadan, 1974.
11. Olurin EO, Timeyin ED, Adenuga MO. Thyroid gland disease in Ibadan, a review. W Afr J Med 1986; 5(2): 147-155.
12. Ebigbo PO, Izuora GI. Draw A Person Test: Standardizatio, Validation and Guidelines for use in Nigeria, University of Nigeria, 1981.
13. Raven JC. Progressive Matrices (1938), 1956 Revision. London Lewis, 1956.
14. John T, Escobar del Rey F. Evaluation of iodine/creatinine ratio of casual samples as indices of daily urine iodine output during field studies. J Clin Endocrionl Metab 1965; 25: 540-543.
15. Thilly HC, Chalula N, Chugston GA, Kavishe FP, DeMaeyar E, Manoff R. Assessment and communication for IDD control programs: Report of an ICCIDD committee. In: Hetzel BS, Dunn JT, Stanbury JB, eds. The Prevention and Control of Iodine Deficiency Disorders. Amsterdam, Elsevier Science Publishers 1987; 143-147.
16. Isichei UP. Towards the prevetion, control and eradication of IDD in Plateau State and the neighbouring North-Eastern States of Bauchi, Gongola, Kano and Borno in the Federal Republic of Nigeria: Past, present and planned future activities. Proceedings fo the National Workshop on IDD in Nigeria. Federal Ministry of Health/UNICEF, Lagos 1991; 37-42.
17. Dunn JT, Haar Vander Frits. A practical guide to the correction of iodine deficiency. Technical Manual No. 3, ICCIDD/UNICEF/WHO, 1989; p 15.
18. Hetzel BS. An overview of the prevention and control of iodine deficiency disorders. In: Hetzel Bs, Dunn JT, Stanbury JB, eds. The Prevention and Control of Iodine Deficiency Disorders. Amsterdam, Elsevier, 1987; 7-13.
19. Hetzel BS. Iodine deficiency disorders (IDD) and their eradication. Lancet 1983; ii: 1126-1129.
20. SEARO/WHO. Iodine deficiency disorders in South-East Asia. Delhi: WHO Regional Office for

South East Asia, SEARO Regional Papers, No. 10, 1985.
21 The prevention and control of iodine deficiency disorders. Resolution 29, 39th World Health Assembly, WHO, Geneva, 1986
22. Follis RH. A pattern of urinary iodine excretion in goitrous and non-goitrous areas. Am J Clin Nutr 1963; 14: 253-268.
23. Konde M, Ingenbleek Y, Dffe M, Sylla B, Barry O, Diallo S. Goirous endemic in Guinea. Lancet 1994; 344: 1675-1678.
24. Hetzel BS, Potter JB, Dulberg EM. The iodine deficiency disorders: Nature pathogenesis and epidemology. In: Bourne GH eds. Aspects of some Vitamins, Minerals, and Enzymes in Health and Disease. World Rev Nutr Diet 1990; 62: 59-119.