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Iodine Deficiency Disorder and Its Association with Academic Performance Among Children in Jimma Town, Southwestern Ethiopia

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Abstract: Nutritional status is the major factor that can affect academic performance of school children. The main aim of this study was to determine the association between iodine deficiency disorder and academic performance among school age children. Both community & school based cross sectional survey was conducted from October 1-30, 2010. A total of 1254 students, aged 6-12 years, were selected from five primary schools using systematic random sampling method. Goiter examinations and urine iodine test was done to diagnose goiter. Spot urine samples were collected to determine median urinary iodine level and anthropometric measurements were done. In this study, 1,254 children were included; 674 (53.7%) were males. Average academic score of students for both sexes was 71.13%. Majority of students 349 (71.2%) who had goiter scored below average (p=0.01). High median urinary iodine level [AOR=0.38; 95% CI (0.190,0.489)]; high height-for-age z-score [AOR=5.023; 95% CI (3.317,7.607)]; and high weight-for-age z-score [AOR=3.214; 95% CI (2.091,4.941]) were significantly associated with good school performance. Iodine deficiency disorder is a significant health problem among schoolchildren in the study area. Strengthening salt iodization program is a preventive measure.

Keywords: Goiter, Iodine Deficiency, Academic Performance, Urinary Iodine

1. Introduction

Iodine is an essential micronutrient for the regulation of physical growth and neural development. Insufficient iodine level in the blood leads to poor production of thyroid hormones. The most visible effect of Iodine Deficiency Disorder (IDD) is goiter, resulting from either low iodine intake or ingestion of goitrogens [1].

Globally more than two billion people are estimated to be at risk of IDD and 260 million people in Africa are at risk and 150,000 are affected by goiter. The most recent national survey of IDD conducted by Ethiopian Health and Nutrition Research Institute (EHNRI, 2005) indicated that a high prevalence of goiter rate as nearly as 40% in school age children and 36% in mothers [2].

Iodine deficiency in the soil affects all forms of plant life and crops grown on iodine depleted soil will have low iodine content. Thus, populations who rely on subsistence agriculture are more likely to be exposed to iodine deficiency if the soil's iodine content is low [3].

Thyroid hormones play an important role in cellular metabolism and early growth and development of most organs, especially of the brain. Consequently, deficiency in iodine and/or in thyroid hormones occurring during this critical period of life will result in slowing down of metabolic activities and irreversible alterations of brain development [4].

Poor academic achievement has been a major area of concern for educators, parents, and students. Poor nutritional

status among school children has significant adverse effects on school progress. There is a direct relationship between prevalence of malnutrition and educational wastage. Malnourished children have difficulties to master school educational materials and have high chances of repeating grades and dropping out early from school [5].

Universal salt iodization program as a preventive means is not strictly controlled in Ethiopia. In 2003 a remarkable progress was made to increase access to iodized salt by training salt producing companies and quality control laboratory technicians. The problem has persisted yet. The main objective of this study is to determine the association between iodine deficiency disorder and academic performance among school age children.

2. Materials and Methods

2.1. Study Design and Area

Cross sectional study design was conducted among school age children in Jimma town from October 1-30, 2010. Samples of 1254 children were selected from five primary schools (Hirmata, Kittoo, Jiren, Mandara & Ginjo) by systematic random sampling method. Sample size was calculated using single population proportion formula by taking overall IDD prevalence of 53.5% [6], 95% confidence interval & 5% non response rate.

A pre-tested structured questionnaire was used for data collection. Academic records were reviewed, physical examination for goiter was done, urinary iodine test and anthropometric measurements were conducted. School document review was done to gather information about the student's grade report and grade averages. School performance during the previous year was obtained from school records. Good school performance was defined as an overall average grade of > 71.13% during the previous academic year.

Iodine Deficiency Disorder (IDD) manifested as goiter was palpated and graded by physicians using standard procedures as per the criteria of WHO/UNICEF/ICCIDD. According to these criteria, goiter was graded as follows: Grade zero: no palpable or visible goiter; Grade 1: a goiter that is palpable but not visible when the neck is in the normal position and Grade 2: A swelling in the neck, that is visible when the neck is in a normal position [7].

2.2. Ethics Approval

Ethical clearance for the study was obtained from the ethical review board of Jimma University, College of Public Health and Medical Sciences. The objective of the study and advantages obtained from the study was clarified to the parents or guardians of the children and written informed consent was obtained from the parents or guardians of the children to undertake the study. Confidentiality was maintained.

2.3. Data Collection

About 5 ml of spot urine samples were collected from sampled students in a properly labeled and sterile urine cups. These cups were immediately transferred to the thermo cool box containing ice bags and were transported to the laboratory. The samples were kept at 4°C in a refrigerator with all precautions until analysis. Analysis of urinary iodine was done using spectrophotometer based on ammonium persulfate method, as suggested and approved by WHO/UNICIEF/ICCIDD [3]. This involves the spectrophotometric analysis of a reaction media which utilizes iodine as a catalyst. During this reaction cerric ammonium sulfate (yellow in color), one of the reactant is reduced to cerrous (colorless) form. The absorbance value (optical density, OD); at 405 nm is inversely proportional to the iodine content of the sample, i.e. the more the absorbance the less is the iodine content. The absorbance value can be used for the determination of the actual iodine concentration using a standard graph prepared by using a range of standard KIO_3 solutions [3].

WHO/UNICEF/ICCIDD recommended that, the iodine deficiency level should be determined in a given community by measuring the level of iodine excretion in the urine. The urinary iodine excretion (UIE) values are compared with established cutoff points to assess the degree of iodine deficiency. Median UIE values less than 20 µg/L indicate severe iodine deficiency, values between 20-49.9 µg/L indicate moderate deficiency, values between 50-99.9 µg/L indicate mild iodine deficiency, and values between 100-199.9 µg/L indicate adequate iodine level [3].

Height was measured to the nearest 0.1 centimeters (cm) on barefoot, participants stood upright against a mounted portable stadiometer (Charder HM200P Portstad). Weight was measured to the nearest 0.1 kilogram (kg), participants lightly dressed (underwear and T-shirt) using a portable digital weighing scale (Tanita HA-623). Anthro plus 3.2.2 was used to calculate the nutritional indices, including weight-for-age percentiles and height-for-age percentiles.

2.4. Data Analysis

Data analysis was done using SPSS version 20 software and association between dependent & independent variables were examined. Chi-Square test analysis was done to see the relationship between school performance and other independent variables. Multiple logistic regression analysis was done to see the effect of all confounding variables on the outcome variable. P value < 0.05 was considered significant.

In order to analyze the nutritional status of the student, their weight and height was converted into z-scores based on the National Center for Health Statistics (NCHS) reference population recommended by the WHO. Thus, those below -2 standard deviations of the NCHS median reference for height-for-age and weight-for-age were defined as stunted and underweight respectively [8].

A low height-for-age z-score (stunting) indicates that slow physical growth since the birth date. This is usually due to repeated episodes of poor nutrition and/or episodes of diarrhea and other illnesses. It is a cumulative indicator of past episodes of malnutrition. A low weight-for-age z-score

(underweight) reflects both stunting and wasting or a low weight-for-height z-score [8].

3. Results

Amongst 7756 school age children in the five primary schools of Jimma town, a sample 1254 students were interviewed and examined, of whom 674 (53.7%) were males and 580 (46.3%) were females. The majority of students, 760 (60.6%) were in the age range of 6-9 years.

The prevalence of goiter among the children was 39.1%, out of which 21.3% had palpable (Grade-1) and 17.8% had visible (Grade-2) goiter. The prevalence of goiter was significantly higher among females 21.4% than in males 17.7% (p=0.001) as shown in table 1.

Academic Performance of school children: Average score of students for both sexes was 71.13%. Regarding the educational status of the father, most of the students 286 (60.3%) who scored below average had illiterate fathers.

As shown on table 1, high goiter prevalence 379 (77.3%) was observed in children whose parent's monthly income is < 2000 Ethiopian birr (p=0.00).

Based on possession index, most of the students who scored above average had the access to toys 494 (75.7%), television 551 (68.7%), and radio 517 (72.6%).

Assessment of urinary iodine concentration (UIC) showed that, 74.9% of children had UIC < 100 µg/L, which is an indicator of iodine deficiency. Among these, 9.6% were severely iodine deficient, 33.7% were moderately iodine deficient, and 31.6% were mildly iodine deficient based on the classification recommended by WHO. Children who had adequate iodine concentration (UIC between 100µg/L and 199.9µg/L) were only 25.1% and the median UIC was 51µg/L.

Children who were moderately iodine deficient had a higher prevalence of goiter (39.6%) than those who had adequate iodine concentration (14.1%). In this study, UIC was significantly correlated with prevalence of goiter (p = 0.02).

Majority of the students 524 (68.6%) with median urinary iodine level < 51 µg/L scored below average academic performance compared to students with median urinary iodine level > 51 µg/L. (Table 3)

Significantly higher number of students 349 (73.6%) who had goiter scored below average academic performance compared to those without goiter 125 (26.4%) (p=0.00). Students with low height for age z-score 362 (70.4%) and low weight for age z-score 356 (66.5%) had low academic performance compared to students with high height for age z-score 112 (15.1%) and high weight for age z-score 118 (16.4%). (Table 5)

Factors associated with goiter: Majority of the children 184 (37.6%) consume cabbage every day. Significantly higher rate of goiter (p=0.001) was observed among children who consumed cabbage everyday 184 (37.6%) than those who never consumed cabbage 22 (4.5%).

Variables which were identified to have significant association (at significance level of 0.05) with goiter in the Chi-Square test analysis were entered into stepwise forward multivariate regression. In multivariate logistic regression model, sex [AOR=4.84, 95%CI (3.25-9.86)], and consumption of common goitrogenic foods like cabbage twice in a week [AOR=8.3; 95% CI (6.32-12.7] had an independent association with goiter. (Table 4)

Factors associated with academic performance: The effects of different variables were tested using multiple logistic regression analysis so as to determine the expected predictors of academic performance.

Children whose fathers monthly income > 2000 Birr [AOR=5.743; 95%CI 4.411-7.477)], absence of goiter [AOR=4.368; 95%CI=2.974-6.414)], greater median urinary iodine level [AOR=0.38; 95%CI=0.190-0.489)], high height for age z-score [AOR=5.023; 95% CI (3.317-7.607)], and high weight for age z-score [AOR=3.214; 95%CI=2.091-4.941)] were associated with high school performance, (Table 5).

4. Discussion

Nutritional status is a major factor that can affect academic performance of schoolchildren. The scientific evidence shows that malnutrition in infants and children is a risk factor in the formal educational system [1]. In the studied area, the total goiter prevalence was 39.1% indicating that IDD is a severe public health problem. This result is in agreement with earlier reports given by Chernet *et al*, who reported the overall goiter rate in Ethiopia to be 39.9% [9].

The prevalence of goiter was significantly higher among females 21.4% than in males 17.7%. This result is in agreement with the study reported by Yinebeb *et al,* [10]. Females are being more vulnerable to goiter than males because of such physiological reasons as puberty occurs 2 years earlier than males. Iodine demand is increased during pubertal period.

High goiter rate was recorded among children from low income family. The higher goiter prevalence among low income category could be associated with poor nutritional intake, less consumption of meat, use of non iodized salt and lack of medical attention. This suggests that living standard is having a direct relation with iodine nutritional status and thereby with high goiter prevalence [10].

A direct correlation was established between the frequency of cabbage intake and goiter prevalence. Those who consume cabbage everyday were 11.5 times more vulnerable to goiter than those who never consume. [AOR 11.5, 95% CI (7.01-18.20)]. This result is in consistent with a report obtained from Ethiopia [11]. This is because; goitrogens contain thiocyanate and isothiocyanate that inhibit the uptake of iodine to the thyroid follicular cells and also blocks the thyroid peroxidase enzyme. In the presence of goitrogen iodination of thyroglobulin protein will be affected, inducing in poor thyroxine production and enlargement of the thyroid.

In the present study, the presence of goiter in school children was independently associated with school performance. Children who had goiter had higher odds of

getting below average score in their school grade compared to those who did not have goiter. Other studies conducted in Malaysia [12] and Tanzania [13] revealed a similar negative effect of iodine deficiency disorder on the academic performance of schoolchildren.

A direct relationship was observed between anthropometric measurement and academic performance. School children having greater than -2 SD of height for age and weight for age z score were scored good school performance. Height and weight have a significant association with learning, suggesting the importance of nutrition in the education system [14]. Other studies have also investigated the associations between height-for-age and school achievement [15]. This may be because of the hypothesis that under nutrition causes poor motor development and subsequent low activity levels. It also causes apathy and lack of interest in the environment. Another possible mechanism is that under nutrition could have a direct effect on the children's central nervous system.

Median urinary iodine level is a valuable indicator of the iodine nutritional status of the entire population. In the present study, the median urinary iodine concentration is 51μg/L, which is below 100 μg/L and this further indicates the presence of iodine deficiency disorder in the studied population. Children with above median urinary iodine level have good school performance compared to students with less median urinary iodine [16].

5. Conclusions

The present study revealed that iodine deficiency goiter is a significant health problem among school age children in the study area. Hypothyroidism due to iodine deficiency reduces physical growth and retards learning capacity. Strengthening salt iodization programs is strongly recommended as a preventive measure.

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Table 1. *Sociodemographic & Socioeconomic Characteristics and Goiter Status of School Children, n=1254.*

Variables	Goiter status			
	Normal n (%)	Present n (%)	Total n (%)	p-value
Sex				
Male	452 (59.2)	222 (45.3)	674 (53.7)	0.05
Female	312 (40.8)	268 (54.7)	580 (46.3)	
Age (year)				
6-9	487 (63.7)	273 (55.7)	760 (60.6)	0.25
10-12	277 (36.3)	217 (44.3)	494 (39.4)	
Frequency of cabbage intake				
Everyday	146 (19.1)	184 (37.6)	330 (26.3)	
3x/week	68 (8.9)	62 (12.7)	130 (10.4)	0.01
2x/week	153 (20.0)	129 (26.3)	282 (22.5)	
1x/week	195 (25.5)	93 (19.0)	288 (23.0)	
Never	202 (26.4)	22 (4.5)	224 (17.9)	
Monthly income (ETB)				
<2000	306 (40.1)	379 (77.3)	685 (54.6)	0.00
≥2000	458 (59.9)	111 (22.7)	569 (45.4)	
Literacy status of the father				
Illiterate	440 (57.6)	270 (55.1)	710 (56.6)	0.21
Literate	324 (42.4)	220 (44.9)	544 (43.4)	
Literacy status of the mother				
Illiterate	506 (66.2)	323 (65.9)	829 (66.1)	0.47
Literate	258 (33.8)	167 (34.1)	425 (33.9)	

Current exchange rate, $1.00 USD = 20.70 ETB, Ethiopian Birr

Table 2. *Association Between Socio Demographic and Socio Economic Variables and Academic Performance of School Children, n=1254.*

Variables	Academic Performance			p-value
	Bellow Average n (%)	Above Average n (%)	Total n (%)	
Sex				
Male	202 (42.6)	472 (60.5)	674 (53.7)	0.03
Female	272 (57.4)	308 (39.5)	580 (46.3)	
Age (year)				
6-9	258 (54.4)	502 (64.4)	760 (60.6)	0.16
10-12	216 (45.6)	278 (35.6)	494 (39.4)	
Monthly income (birr)				0.00
<2000	375 (79.1)	310 (39.7)	685 (54.6)	

Variables	Academic Performance			p-value
	Bellow Average n (%)	Above Average n (%)	Total n (%)	
≥2000	99 (20.9)	470 (60.3)	569 (45.4)	
Literacy status of the father				
Illiterate	286 (60.3)	424 (54.4)	710 (56.6)	0.02
Literate	188 (39.7)	356 (45.6)	544 (43.4)	
Literacy status of the mother				
Illiterate	316 (66.7)	513 (65.8)	829 (66.1)	0.39
Literate	158 (33.3)	267 (34.2)	425 (33.9)	
Availability of toys				
Yes	159 (33.5)	494 (63.3)	653 (52.1)	0.03
No	315 (66.5)	286 (36.7)	601 (47.9)	
Availability of television				
Yes	251 (53.0)	551 (70.6)	802 (64.0)	0.02
No	223 (47.0)	229 (29.4)	452 (36)	
Availability of radio				
Yes	195 (41.1)	517 (66.3)	712 (56.8)	0.04
No	279 (58.9)	263 (33.7)	542 (43.2)	
House ownership				
Our own	222 (46.8)	564 (72.3)	786 (62.7)	0.39
Rent	227 (47.9)	189 (24.2)	416 (33.2)	
Don't know	25 (5.3)	27 (3.5)	52 (4.1)	

Current exchange rate, $1.00 USD = 20.70 ETB, Ethiopian Birr

Table 3. *Association Between Urinary Iodine Excretion Level and Academic Performance of School Children, n=1254.*

Urinary iodine excretion (µg/L)	Goiter status			
	Normal n (%)	Goitrous n (%)	Total n (%)	P value
<20	69 (9.0)	51 (10.4)	120 (9.6)	0.02
20-49.9	229 (30.0)	194 (39.6)	423 (33.7)	
50-99.9	220 (28.8)	176 (35.9)	396 (31.6)	
100-199.9	246 (32.2)	69 (14.1)	315 (25.1)	
Median urinary iodine (MUI)=51 µg/L	Academic performance			
	Bellow average n (%)	Above average n (%)	Total n (%) P value	
< 51 µg/L	524 (68.6)	66 (13.5)	590 (47.0)	0.05
≥ 51 µg/L	240 (31.4)	424 (86.5)	664 (53.0)	
Goiter status				
Normal	125 (26.4)	639 (81.9)	764 (60.9)	0.01
Goitrous	349 (73.6)	141 (18.1)	490 (39.1)	

Table 4. *Predictors of Goiter Among School Children, n=1254.*

Variables	Goiter status		AOR 95% CI
	Normal n (%)	Present n (%)	
Sex			
Male	452 (59.2)	222 (45.3)	1.00
Female	312 (40.8)	268 (54.7)	4.84 (3.25-9.86)
Monthly income (ETB)			
<2000	306 (40.1)	379 (77.3)	0.196 (0.151-0.253)
≥2000	458 (59.9)	111 (22.7)	1.00
Age (year)			
6-9	487 (63.7)	273 (55.7)	0.79 (0.69-3.59)
10-12	277 (36.3)	217 (44.3)	1.00
Frequency of cabbage intake			
Everyday	146 (19.1)	184 (37.6)	11.5 (7.01-18.20)*
3x/week	68 (8.9)	62 (12.7)	7.7 (4.7-14.63)
2x/week	153 (20.0)	129 (26.3)	83 (6.32-12.7)
1x/week	195 (25.5)	93 (19.0)	0.9 (0.71-1.96)
Never	202 (26.4)	22 (4.5)	1.00
MUI (51µg/L)			
<51µg/L	240 (31.4)	424 (86.5)	14.02 (10.38, 18.95)*
> 51µg/L	524 (68.6)	66 (13.5)	1.00

*Significance at p<0.05, Current exchange rate, $1.00 USD = 20.70 ETB, Ethiopian Birr

Table 5. *Predictors of Academic Performance Among School Children, n=1254.*

Variables	Academic Performance		AOR 95% CI
	Bellow mean n (%)	Above mean n (%)	
Sex			
Male	202 (30.0)	472 (70.0)	1.844 (0.255-2.710)
Female	272 (46.9)	308 (53.1)	1.00
Monthly income (ETB)			
<2000	375 (79.1)	310 (39.7)	1.00
≥2000	99 (20.9)	470 (60.3)	5.743 (4.411-7.477)*
Literacy status of the father			
Illiterate	286 (60.3)	424 (54.4)	0.370 (0.242-1.594) 1.00
Literate	188 (39.7	356 (45.6)	
Availability of Toys			
Yes	159 (24.3	494 (75.7)	1.420 (0.938-2.176)
No	315 (52.4	286 (47.6)	1.00
Availability of Television			
Yes	251 (31.3)	551 (68.7)	0.872 (0.551-1.380)
No	223 (49.3	229 (50.7)	1.00
Availability of Radio			
Yes	195 (27.4)	517 (72.6)	2.637 (0.767-3.935)
No	279 (51.5	263 (48.5)	1.00
Going to bed hungry			
Yes	256 (44.9)	314 (55.1)	0.671 (0.449-1.002)
No	218 (31.9	466 (68.1)	1.00
Goiter status			
Normal	125 (16.4)	639 (83.6)	4.368 (2.974-6.414)*
Goitrous	349 (71.2	141 (28.8)	1.00
Median urine iodine level (51µg/l)			
Bellow mean	408 (61.4)	256 (38.6)	1.00
Above mean	66 (11.2)	524 (88.8)	0.38 (0.190-0.489)*
Height for age Z score			
High (>-2 SD)	112 (15.1)	628 (84.9)	5.023 (3.317-7.607)*
Low (<-2 SD)	362 (70.4	152 (29.6)	1.00
Weight for age Z score			
High (>-2 SD)	118 (16.4)	601 (83.6)	3.214 (2.091-4.941)*
Low (<-2 SD)	362 (70.4	152 (29.6)	1.00
Families encourage education			
Yes	239 (27)	645 (73)	1.30 (0.837-2.930)
No	235 (65.5	135 (36.5)	1.00
Shortage of educational material			
Yes	287 (47.2)	393 (57.8)	0.17 (0.024-1.394)
No	187 (32.6	387 (67.4)	1.00

*Significance at p<0.05, Current exchange rate, $1.00 USD = 20.70 ETB, Ethiopian Birr

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