Iodine Intake, UIE Levels, Nutritional Status and Academic Achievements in School-Age Children in Magelang, Central Java

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Abstract

Iodine deficiency in school children is estimated at 25% worldwide. Complete brain development occurs at the age of 7 years and the development of cognitive function can be increased until 15 years with normally iodine status, namely adequate intake of iodine and Urinary Iodine Excretion (UIE). This study aims to analyze the relationship between iodine intake, UIE, height for age and academic achievements in school-age children. This research was an analytic observational study with a cross sectional design. This research was conducted in 4 elementary schools in Pakis District in March 2019. The samples were selected by random sampling, totaling 177 subjects. The dependent variable was the school's academic achievements in the form of midterm exam scores for maths, arts and sports. While the independent variables were iodine intake, UIE and height for age. The assessment of iodine intake was using a 24-hour recall form and interpreted using the 2007 Nutrisurvey application. The analysis method for UIE is the acid digestion method. Height for age is a child's nutritional status that can be determined based on anthropometric measurements. Academic achievements is learning outcomes as measured by midterm exam scores iin maths, arts, culture and sports. Data was analyzed by Linear Regression. Iodine intake increased math (b=0.01; p=0.014), art and sport (b=0.03; p=<0.001) scores. UIE levels increased math (b=0.01; p=0.001), art (b=0.01; p=0.002) and sport (b=0.01; p=0.003) scores. Height for age increased sport scores (b=1.58; p=0.010). The conclusion of this study is that height for age increase sports ability and iodine intake also UIE can increase academic achievements.

Keyword: Academic Achievements, Height for Age, Iodine Intake, UIE

INTRODUCTION

Iodine Deficiency Disorders (IDD) is a nutritional problem that is one of health concern to WHO. Iodine deficiency occurs in 130 countries in the world and iodine deficiency in school children is estimated at 25% (A. C. Carvalho et al., 2018). Iodine deficiency can cause developmental disorders of the central nervous system and brain damage, psychomotor disturbances and deficits in Intelligent Quotient (IQ) (Bailote et al., 2022). Iodine deficiency is a common cause of childhood brain damage that can be prevented if the right steps are taken early (Choudhry et al., 2018).

Low iodine intake in the long term will experience an IQ deficit of 50 points and babies born in endemic areas of disorders due to iodine deficiency are at risk of an IQ deficit of 13.5 points (Cui et al., 2020). Research Carvalho et al., (2018) stated that in school-age children

there were also cases of excess iodine. Excessive iodine intake results in thyroid dysfunction as well as iodine deficiency (Farebrother et al., 2019). Thyroid hormone plays an important role in brain development (Babić Leko et al., 2021) . The most common thyroid disorders resulting from excess iodine intake are autoimmune thyroid disease, nodular goiter and iodine-induced hyperthyroidism (Winder et al., 2022). WHO recommends that the optimal intake of iodine for children aged 6-12 years is 120 µg per day to prevent iodine deficiency and thyroid dysfunction (Koukkou et al., 2017).

Urinary Iodine Excretion (UIE) is an indicator of iodine status, because most of the iodine absorbed by the body will be excreted in the urine and can reflect current iodine intake and recent changes in a person's iodine status (Campanozzi et al., 2019). Examination of UIE a sensitive marker to determine a long-term effect of iodine intake for months to years (Beckford et al., 2022). Adequate intake of iodine can increase complete brain development at the age of 7 years until 15 (Murcia et al., 2018). For school-age children, this period is the stage where motoric and physical abilities develop, children begin to be aware of themselves and the world around them and try to achieve independence, social adaptation, development and progress in learning (Yu et al., 2018). Iodine status is an illustration of what elementary school children consume in the long term and their metabolism plays a role in thinking or reasoning processes as well as concentration power and is closely related to learning efficiency (Carvalho et al., 2022). The high geographical risk of iodine deficiency and thyroid dysfunction also underlies that attention regarding iodine must be increased, especially in populations that are vulnerable to endemic IDD such as school children (Du et al., 2022).

Height for age plays a role in improving the academic ability of school children. Research Akubuilo et al. (2020) at aged 6-12 years showed that school children who have normal height had better academic scores. Children who are stunted have lower cognitive and academic scores compared to children who have normal height for age. Research Mansukoski et al. (2020) showed that poor growth characteristics at height for age were negatively related to non-verbal IQ scores. Meanwhile, IDD endemic areas are at risk for the physical development of school children which can lead to stunting (Li et al., 2020).

Magelang District has highland geographical conditions that allow the area to become an endemic risk for IDD due to the lack of mineral reserves in the soil (BPS, 2018b). One of the subdistricts that is located high above sea level is Pakis with an altitude of 841 meters above sea level (mdpl) (BPS, 2018). The percentage of village coverage in the category of good iodized salt in Magelang District in 2019 was still 73.39% (Dinkes, 2017). This shows that public awareness about the importance of iodine in efforts to prevent IDD is still lacking. Based

on this data, this research was conducted to look at the iodine status of school children and its relationship with academic achievement.

METHODS

This research was conducted with an analytic observation approach and used a cross sectional design. The research was conducted in Pakis Subdistrict, Magelang, Central Java from March to April 2019. The population in this study were school children aged 6–12 years who were grades 1–6. A sample of 177 subjects was obtained through simple random sampling.

The dependent variable in this study is the ability of school academics as assessed from the midterm exams in maths, arts and sports. The independent variables were iodine intake, UIE, and height for age. Iodine intake is the total intake of iodine consumed in a day (24 hours) which is absorbed from food sources of iodine. The assessment of iodine intake was carried out by enumerators of nutritionists using a 24-hour recall form and interpreted using the 2007 Nutrisurvey application. Based on the Recommended Dietary Allowances (RDA), the need for iodine intake is 120 µg, the population intake level is said to be adequate if the intake is ≥77 percent of the RDA and is said to be inadequate if the intake level of iodine is <77 percent of the RDA.

Urinary iodine status is the amount of UIE which can describe individual and population iodine consumption. Urine collection was carried out by the subject assisted by parents by collecting the first morning urine in a urine pot then collected to the enumerator. The subject's urine sample was given an identity (respondent code) and the date the urine was collected was recorded. The instrument used was a 50 ml plastic opaque urine pot. The enumerator sent a urine sample using a plastic container for analysis in the laboratory. The analysis method for UIE is the acid digestion method by first shaking the urine and then taking 10 cc and dissolving it with ammonium persulfate at 90-110ºC and then adding ceric ammonium sulfate. The yellow color change that occurs is measured quantitatively with a spectrophotometer and the threshold is 100-200 µg/L. The UIE is said to be excessive if the level is ≥ 200 µg/L and it is said to be deficient if its level is <100 µg/L.

Height for age is a child's nutritional status that can be determined based on anthropometric measurements. Height was measured using a microtoise with an accuracy of 0.1 cm. Height for age was obtained by comparing the value of height with the Z score using the WHO Anthroplus 2005 software application. Height for age was mentioned to be normal if it was on the threshold of Z Score -2 SD to +2 SD.

Academic achievements is learning outcomes as measured by midterm exam scores in Semester II in maths, arts, culture and sports. The collection of test scores is obtained through secondary data from the teacher. The measurement scale used for all variables is continuous data. Univariate analysis was performed to determine the frequency distribution of the subject characteristics. Bivariate analysis was conducted to determine the relationship between iodine intake, UIE, height for age and academic achievements using the Pearson Correlation Test. Multivariate analysis was using Linear Regression.

RESULTS

Univariate analysis

Univariate analysis was performed to explain the frequency distribution of the characteristics of respondents. The results of the analysis can be seen in Table 1.

Table 1. Univariat Analysis

Variable	n	Mean	SD	Min	Max
Age	177	9.14	1.78	6	12
Height for Age	177	-1.53	0.97	-4.21	1.11
Iodine Intake (µg)	177	134.50	105.32	12.7	427.56
UIE (µg/L)	177	270.99	158.71	29	852
Math Scores	177	63.85	0.63	62.59	65.11
Art Scores	177	65.12	0.57	63.98	66.26
Sport Scores	177	66.79	0.64	65.51	68.07

Table 1 shows the univariate results that the respondents had an average age of 9 years with the youngest was 6 years and the oldest was 12. The average Z score for height for age of this study was -1.53 with a minimum score of -4.21 and a maximum of 1.11. The respondent's iodine intake variable had a mean of 134.50 µg per day with the lowest intake being 12.7 µg per day and the highest intake being 427.56 µg per day. The respondent's UIE had an average of 270.99 µg/L with the lowest level being 29 µg/L and the highest being 852 µg/L. The respondent's academic achievements from the average math score is 63.85 with the lowest math score is 62.59 and the highest score is 65.11. The average score of art was 65.12 with the lowest score being 63.98 and the highest score being 66.26. The sports scores of the mid term had an average of 66.79 with the lowest score being 65.51 and the highest being 68.07.

Bivariate analysis

Bivariate analysis was performed to determine the relationship between iodine intake, UIE, height for age and the scores of math, art as well sport of elementary school children.

Table 2. Correlation between Iodine Intake, UIE , Height for Age and Math Scores

Variable	Correlation Coefficient (r)	p
Iodine Intake	0.26	0.001
UIE	0.31	<0.001
Height for Age	0.05	0.498

Table 2 shows that school children's iodine intake has a positive relationship with math scores and is statistically significant (r= 0.26; p= 0.001). UIE had a positive relationship with math scores and was statistically significant (r= 0.31; p= <0.001). Height for age of elementary school children had a positive relationship with math scores but not statistically significant (r= 0.05; p= 0.498).

Table 3. Correlation between Iodine Intake, UIE, Height for Age and Art Scores

Variable	Correlation Coefficient (r)	p
Iodine Intake	0.49	<0.001
UIE	0.33	<0.001
Height for Age	0.03	0.669

Table 3 shows that elementary school children's iodine intake has a positive relationship with art scores and is statistically significant (r= 0.49; p=<0.001). The UIE had a positive relationship with art scores and was statistically significant (r= 0.33; p=<0.001). Height for age of elementary school children has a positive relationship with art scores but not statistically significant (r= 0.03; p= 0.669).

Table 4. Correlation between Iodine Intake, UIE, Height for Age and Sport Scores

Variable	Correlation Coeeficient (r)	p
Iodine Intake	0.39	<0.001
UIE	0.34	<0.001
Height for Age	0.20	0.008

Table 4 shows that elementary school children's iodine intake has a positive relationship with sport scores and is statistically significant (r= 0.39; p=<0.001). The UIE had a positive relationship with sports scores and was statistically significant (r= 0.34; p=<0.001). Height for age of elementary school children has a positive relationship with sports scores and is statistically significant (r= 0.20; p= 0.008).

Multivariate analysis

Multivariate analysis was performed using Linear Regression Test. The multivariate explains the relationship of the independent variables (iodine intake, UIE, height for age) with the dependent variables namely math, art and sport values.

Table 5. Multiple Linear Regression Analysis of The Relationship between Iodine Intake, UIE and Math Scores

Variable	b	CI (95%)		p
		Lower Limit	Upper Limit	
Iodine Intake	0.01	<0.01	0.03	0.014
UIE	0.01	<0.01	0.02	0.001
n observation = 177 R squared = 12.77% p<0.001				

The results of the analysis can be seen in Table 5 showing that statistically there is a significant relationship between iodine intake and UIE with math scores. The results of the analysis showed that there was a positive relationship between iodine intake (b=0.01; 95% CI <0.01 to 0.03; p= 0.014) and UIE (b=0.01; 95% CI <0.01 to 0.02) with math scores. Iodine intake and UIE have weak strengths in increasing the math scores of elementary school children. The R squared value shows the contribution of iodine intake and UIE of 12.77% towards math scores and as much as 87.23% is obtained by other factors outside the independent variables.

Table 6. Multiple Linear Regression Analysis of The Relationship between Iodine Intake, UIE and Art Scores

Variable	b	CI (95%)		p
		Lower Limit	**Upper Limit**	
Iodine Intake	0.03	0.02	0.04	<0.001
UIE	0.01	<0.01	0.02	0.002
n observation = 177 R squared = 27.26% p<0.001				

The results of the analysis can be seen in Table 6 showing that statistically there is a significant relationship between iodine intake and UIE with art scores. The results of the analysis showed that there was a positive relationship between iodine intake (b=0.03; 95% CI 0.02 to 0.04; p= <0.001) and UIE (b=0.01; 95% CI <0.01 to 0.02; P= <0.002) with art scores. Iodine intake and UIE have weak strengths in increasing the art scores of elementary school children. The R squared value shows the contribution of iodine intake and UIE of 27.26% towards art scores and the other 72.74% is obtained by other factors outside the independent variables.

Table 7. Multiple Linear Regression Analysis of The Relationship between Iodine Intake, UIE, Height for Age and Sport Scores

Variable	b	CI (95%)		p
		Lower Limit	Upper Limit	
Iodine Intake	0.03	0.02	0.04	<0.001
UIE	0.01	<0.01	0.02	0.003
Height for Age	1.58	0.39	2.78	0.010
n observation = 177 R squared = 24.01% p<0.001				

The analysis results in Table 7 show that there is statistically significant relationship between iodine intake, UIE and height for age with sport scores. The analysis showed that there was a positive relationship between iodine intake (b=0.03; 95% CI 0.02 to 0.04; p= <0.001), UIE (b=0.01; 95% CI <0.01 to 0.02; p= 0.003) and height for age (b=1.58; 95% CI 0.39 to 2.78; p= 0.010) towards sport scores of elementary school children. Iodine intake and UIE have weak strength in increasing sports scores, however, the nutritional status of height for age elementary school children can increase 1.58 units of sport scores. Students who have normal height indicates higher sports scores. The R squared value indicates the contribution of iodine intake and UIE of 24.01% to the sport scores and another 75.99% is obtained by other factors outside the independent variables.

DISCUSSION

Iodine is a micronutrient that the body needs to synthesize thyroid hormone and is essential for growth, especially for neurological development (Sorrenti et al., 2021). Almost all food sources have very low or no iodine content, but the best sources of iodine are seafood and animal-based dairy products (Nerhus et al., 2019). Inadequate intake of iodine chronically can reduce a number of cognitive abilities and decrease intelligence (Hatch-McChesney & Lieberman, 2022). Moderate levels of iodine deficiency can also cause growth disorders (Beckford et al., 2017).

In some individuals who have a history thyroid disorders, even a slight increase in iodine intake can trigger thyroid disorders (Bauer, 2019). Daily iodine intake should not exceed 500 µg/day, especially in countries with a history of iodine deficiency (Urmatova et al., 2021). According to the 2013 RDA, the adequate daily iodine intake for Indonesian elementary school children is 120 µg/day (Kemenkes, 2020). However, the impact of preventing iodine deficiency is prioritized because it can prevent bad cognitive decline compared to the effects of excess iodine intake (Shan et al., 2021); (Adinda et al., 2019). Globally, efforts to reduce iodine deficiency in vulnerable populations such as school children and pregnant women are a public health problem that is still being faced (Rodriguez-Diaz & Pearce, 2020).

The results of this study indicate that there is a relationship between iodine intake and the academic abilities of elementary school children. This academic achievement can be seen from several indicators and one of them is the results of elementary school students' midterm examination scores. Elementary school children who have adequate iodine intake can increase 12.77 units of value in maths (b= 0.01; 95% CI <0.01 – 0.03; p= 0.014) and increase 27.26 units of art score (b= 0.03; 95% CI 0.02 – 0.04 ; p = <0.001) and increased 24.01 units of sport score (b = 0.03; 95% CI 0.02 – 0.04; p = <0.001). This is in line with research conducted by Faught et al. (2017) showed that school children who did not suffer from iodine deficiency had better academic abilities than those who were deficient even though they had taken into account their parents' education and school absences. School children who are given iodine capsule supplementation also have better mental performance for their school academics (Angermayr & Clar, 2018).

The average intake of iodine in elementary school children in this study was 134.50 µg/day, with the lowest intake being 12.7 µg/day and the highest intake being 427.56 µg/day. Compairing with the 2013 RDA requirement, the intake level is adequate. Research conducted by Andersson et al. (2020) showed that the tendency of iodine intake in elementary school children in Switzerland has increased to become adequate with efforts to supplement iodine in household salt. Research by Prangthip et al. (2021) stated that school children who consumed a balanced nutritional intake had better academic performance in terms of exams, attendance at school and were able to do better school assignments than children who consumed a diet with an unbalanced nutritional intake. This shows that optimal and balanced nutritional intake between macronutrients and micronutient, especially iodine, has a role in improving the academic abilities of school children.

UIE are a reflection of 85-90% of daily iodine consumption (Faught et al., 2017). UIE is normal if the median daily iodine level is within the range of 100 – 200 µg/L. Iodine status can describe whether a person has iodine deficiency or has excess iodine (Korobitsyna et al., 2022). The mean UIE of school children was 270.99 µg/L with a minimum value of 29 µg/L and a maximum of 852 µg/L. This showed that the average level of iodine in the urine of school children is more than sufficient. Research in several European countries shows that countries that have implemented iodine fortification report an increase in the prevalence of excess iodine levels among elementary school children (Outzen et al., 2022).

Research conducted at Mexico in children aged 6-12 years showed that there was an increasing trend in the iodine status of school children where school children had excess UIE (Galván et al., 2020). This is a report that must be monitored and re-evaluated in iodine

deficiency alleviation programs. Excess UIE are associated with an increased risk of hyperthyroidism and autoimmune thyroid diseases, although in some people these conditions can be tolerated (Kaplowitz & Vaidyanathan, 2020). However, the risk of excess iodine is still considered low compared to the impact of iodine deficiency which can damage the cognitive abilities of human resources (Costa Leite et al., 2017).

On average, children born in IDD endemic areas have an 13.5 point IQ lower than children born in non IDD endemic areas (Yadav & Pandav, 2018). School children are a vulnerable group to experience iodine deficiency and this has an impact on damage to brain development, cognitive and academic abilities that affect the development of human resources and affect the quality of a country (Muktar et al., 2018). Research (Andersson et al. (2020b) stated that an average increase of one point in IQ by controlling for the prevalence of iodine deficiency is associated with an increase of 0.11 percent of the country's Gross Domestic Product (GDP), thereby reducing the prevalence of iodine deficiency contributing to growing 1.5 percent of the country's GDP annually.

The results of this study indicate that there is a relationship between UIE and the academic abilities of elementary school children. Elementary school children who have high UIE can increase 12.77 units of value in mathematics (b= 0.01; 95% CI <0.01 – 0.02; p= 0.001) and increase 27.26 units of artistic value (b= 0.01; 95% CI <0.01 – 0.02; p= <0.002) and increased by 24.01 sport value units (b= 0.01; 95% CI <0.01 – 0.02; p= 0.003). This is in line with the research of Lam & Lawlis (2017) which states that increasing urine iodine levels is proven to improve the cognitive function of fluid intelligence related to solving logical and non-verbal problems, crystallized intelligence which functions for skill abilities and the use of language vocabulary. In addition, iodine levels also affect attention span and concentration in learning. So that better iodine status contributes to improving thinking skills and agility in learning subjects at school. However, this is not in line with the research in school children aged 6-10 years that iodine status is not significantly related to cognitive school children (Hisada et al., 2022).

Cognitive function will be well maintained if a person does not have iodine deficiency. Iodine regulates blood flow transportation to the brain, but iodine cannot play a role alone in improving cognitive function (Lam & Lawlis, 2017). Brain development and cognitive function are also influenced by iron, zinc, folic acid, vitamin B6 and vitamin A (Prado et al., 2017). Even though the iodine status of school children's UIE is high, if the status of other micronutrients is low, cognitive function does not develop optimally (Muhammad et al., 2022).. Multiple micronutrients can increase myelin production for neurotransmitter synthesis, neuron

migration, methylation processes and affect the function of the hippocampus which is useful for learning and memory processes (Fila et al., 2021).

Height for age can reflect the accumulation of malnutrition over the years which has an impact on stunting (Mulyaningsih et al., 2021). Stunting is an indicator of chronic malnutrition in children which can be seen from 2 years of life (Nabwera et al., 2022). Stunting is a high risk factor for school children to get cognitive scores and low academic results (Cameron et al., 2021). The condition of stunting in school children also increases anxiety, depression and low self-esteem compared to school children who have normal height (Mireku et al., 2020).

In this study, the mean height-for-age nutritional status (of school children was -1.53 with a minimum value of -4.21 and a maximum of 1.11. This shows that the average height for age of school children is normal, with the maximum height for age nutritional status being normal but the lowest height for age nutritional status is very short. The results of this study indicate that there is a relationship between height for age and sport scores. Elementary school children who have normally height can increase 24.01 sports value units (b= 1.58; 95% CI 0.39 – 2.78; p= 0.010). This is in line with the research of which states that the cognitive development of children aged 5-12 years can be influenced by height for age, the better the nutritional status of a height for age, the better their cognitive development and physical development will be (Suryawan et al., 2022).

CONCLUSIONS

Based on the results of this research, it can be concluded that Iodine intake and UIE are associated with increased academic achievement such as math, art and sports scores. Height for age is associated with increased exercise ability. It is recommended for school-age children to consume sufficient iodine from seafoods and to use iodized salt for household for the growth and development of their cognitive capacity.

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