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Research Article

Dietary Mineral Imbalance among Primary School Children in Benghazi

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Abstract

Introduction: Childhood is the entire blueprint of an individual's future life, experiences in early and middle childhood are extremely important for a child's healthy development and lifelong learning.2 How a child develops during this time affects future cognitive, social, and emotional, language, and physical development, which in turn influences school readiness and later success in life.3,4 The major objectives of this study was to explore the macro- and micro-minerals intake and dietary patterns among school children

Methods: A cross-sectional study was conducted on N= 150 school age children in Benghazi with most age range from 9 to12 years. The usual dietary intake was assessed by using Food Frequency Questionnaire and dietary records. Major dietary patterns were identified by factor analysis using SPSS program.

Results: This study indicated that there was association between minerals intake and gender. The Females were more consumed below the Recommended Daily Intake of calcium , potassium , magnesium , iron and zinc than males (69% , 56% , 63% , 65% ,65% respectively).While phosphorus intake was exceed Recommended Daily Intake among males than females. Around half of children 58.7% didn't have weight changes after starting school and 22.1% of them had increased in their body weight. Further association in this study was between iron and potassium intake and socioeconomic status. Children with good economic status consumed below the RDA of iron and potassium than excellent economic status.

Conclusion: The current study concluded that there was a dietary minerals imbalance among school children. More females consumed dietary minerals below the RDA than males. This study also found significant association between the minerals intake among school children and socioeconomic status. Education programs for both mothers and students should be established to help children raise awareness on healthy eating behaviors and adequate dietary intake.

Keywords: Minerals imbalance. Micronutrient. Trace elements. Dietary intake. School children. Child eating pattern. Minerals intake. Minerals intake and gen

Introduction

Childhood is the entire blueprint of an individual's future life, evidences show that experiences in early and middle childhood are extremely important for a child's healthy development and lifelong learning. How a child develops during this time affects future cognitive, social, emotional, language, and physical development, which in turn influences school readiness and later success in life 1-3 .Researches on a number of adult health and medical conditions points to pre-disease pathways that have their beginnings in early and middle childhood 2,4,5. One of those experiences is the neglected part of nutrition "the dietary mineral imbalances", where poor dietary planning is frequently practiced, leaving minerals both imbalanced and out of their proper ratio, leading to catastrophic outcomes. Likewise a lot of studies pointed out deficiency or excess of a minerals may cause disorders in absorption, distribution, metabolism and elimination of other elements/minerals or even chronic degradation diseases 2,6,7. Therefore, it's crucial to fulfill the required amounts of the micronutrients "minerals" especially in the childhood phase of life and not to neither exceed nor lesson the proper RDAs (Recommended dietary allowance).

Evidences from previous studies targeting dietary minerals demonstrate that although the human body needs small amount from these nutrients, mineral deficiency and /or excess will affect health status and cause many disorders.

First of all, Worldwide nearly 1 billion adults have hypertension and around 30% of hypertension cases are caused by excess dietary sodium intake 8,9. A significant number of children also have elevated (Blood Pressure) BP levels without having any underlying disease. High levels of BP in childhood may lead to hypertension and other cardiovascular diseases in later life 10,11 as well as contributing to early vascular damage.12,13 . The center for diseases control and prevention (CDC) in the U.S measured the average consumption of salt in the U.S and concluded that Over 90% of U.S. school-aged children

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and adolescents consume too much sodium 14 with more than three fourths of sodium intake estimated to come from commercially processed packaged and restaurant foods 15. In addition, two previous studies were conducted in Australia and Iran found that 87% and 70% of school children consumed exceed recommended level intake of sodium, respectively 16,17 and 48% of this consumption coming mostly from ultra-processed food16.

Moreover, in the fact of the metabolic reaction, excess dietary phosphorus intake interfere with calcium absorption. Asurvey in Greece aimed to record the food habits and nutrient intake of Greek children (1936 children aged 2–14 years old) resulted with 100% of children had phosphorus intake two to four times greater than the RDA. Their Ca:P ratio intake was below the safe levels and showed a progressive decrease with age18. A case-control study was conducted in Mexico also indicated that a significant negative correlation (r= -0.41; p <0.001) between the serum Ca level and the number of bottles of soft drink consumed each week. This study found 66.7% of children with hypocalcemia cases drunk more than four bottles of soft drink per week19.

There are evidences from literature review demonstrated that most of school age children have calcium and vit D deficiency. 20,21 Previous study indicated that only 12% of students consumed the recommended adequate intake of calcium (1300mg/day), and 16% of them consumed vitamin D at the daily recommended level (200 IU/day). There was also significant relation between sex and socioeconomic status and calcium intake among school children. Boys had a significantly higher mean daily calcium intake than girls , and children with high income were more consuming calcium and vitamin D than those with low income. 21 Eating breakfast and physical activity were other factors related to daily calcium and vitamin D intake.

In several epidemiological studies confirmed that selenium deficiency cause several serious short and long- term medical implications, 22-30. A number of studies targeted children found that dietary selenium intake was lower than their RDA . 31,32 a Cross sectional study was conducted on 573 Madrid school children aged 8 - 13 years indicated that low selenium intake along with its relationship with the rising epidemic "childhood obesity". Children with excess of weight (BMI>P85) had lower serum selenium concentrations than those of normal weight (64.6 ± 16.8 μg/L compared to 75.3 ± 12.2 μg/L; p < 0.001). This situation could be more evident in children with central adiposity where they will experience Lower immunity, lower growth and repair. 31 A Chinese study have also proved that selenium's association with children's cardiac health. Keshan disease was Endemic in children aged 2–10 years and in women of childbearing age, this disease occurs in selenium-deficient areas.33

Additionally, Iron deficiency anemia related to some diseases and deficient in some vitamin in school children are also proved . Data from previous study was conducted in Alaska on 700 school age children confirmed that the high prevalence of iron deficiency persists among children.34 This study also showed that active Helicobacter pylori infection was independently associated with iron deficiency. Moreover , Previous studies confirmed that there strong relationship between iron and zinc in case of deficiency in children, and these studies also recommended that children should be consuming supplementation to improve their health.35,36. A cross-sectional study was conducted in East Iran showed that Zinc deficiency was common in elementary school children. 35

There are a number of studies indicated that a lack of magnesium in diet associated with some diseases and psychological disorder. Longitudinal cross sectional showed that low magnesium intake was associated with decreased lung function, especially for flows among girls with asthma. Boys also showed decreased forced vital capacity with low magnesium intake.37 Cohort Study applied on 2,566 children aged 11–19 years who attended schools in 12 southern California communities during 1998–1999 indicated that low magnesium intake is prevalent in the general population of children, and the lung function deficits associated with low magnesium may have a substantial impact on respiratory health at the population level.38 Furthermore, a cross-sectional study in Virginia demonstrated that obese children have lower serum magnesium concentrations than lean children and was associated with insulin resistance IR is present during childhood.39

There strong evidences that mineral imbalance among children affect the education level and academic achievement in school. A cohort study included 1656 Chinese, was examined the relationship between serum copper levels and memory status in children aged 10–14 years. This study found that copper has been linked to brain function and cognitive performance in humans.40 Another follow up study carried on 256 children in Denizli city center found that the serum levels of copper, cadmium and lead were significantly higher in children with adequate intake of RDA than those off controls. 41

In the meta-analyses of three randomized controlled trials with five comparisons in children, increased potassium intake decreased systolic blood pressure and diastolic blood pressure. Another study, a cohort study, resulted in that potassium intake was inversely related to the rate of increase in blood pressure over a seven year period; the highest third of potassium intake had lower increase in blood pressure than the lowest third. Other studies also linked its high intake with lower stroke incidents.42 Moving toward respiratory health a cross-sectional study among 2593 males subjects aged 9 to 16 years was conducted in (Italy) showed that personal table salt use is related to an increased prevalence of bronchial symptoms in males; also, bronchial responsiveness appears to increase with higher potassium excretion in males. 43 As for its intake multiple studies revealed that potassium is neglected, one cross-sectional study, which was conducted on elementary school children (8–10 year olds), in Portugal reported a low compliance of potassium intake recommendations in. 44

The importance of this study comes from, the impact of dietary mineral intake, and the fact that this study is the first study on mineral imbalances among school age children in Benghazi specially designed to analyze their meals , assess dietary minerals intake, evaluate their effects on life style behavior, school achievement and on overall health and to study any factors leading to this mineral imbalance, and eventually to set a database for other studies on related topics.

Methodology

A cross-sectional study was conducted by multistage, stratified random sampling on n=15 primary schools of Benghazi city, Libya in the period between 1st of January to the 15th March 2020. To examine the minerals dietary intake, along other dietary factors, a total of n= 250 schools children aged 5-12 years old who attended both (private and public) schools were recruited to complete a questionnaire. A total of n= 250 students of both sexes were received a questionnaire, 70 of children were excluded because their parents did not return the questionnaire, and 30 of them were eliminated because of recall and information bias , finally n=150 of children were included (46% boys and 54% girls)

Questionnaire:

The questionnaire for this study was based on 21 items divided into 6sections. The first section was about demographics and personal information about school children and their parents which included age, sex , educational level , occupation , income , and number of children. The second section was asked about the health status of children and their medical history. In the next section was examined the changes in health status of children after starting school and their academic achievement. The fourth section was about eating habits, practicing and level of activity of children. The following section was included weight and height measurements and laboratory investigation. The last section included a whole page of instructions for the caregivers as a reminder and to follow prior a 3-day diary record to choose one complete day for analysis and FFQ as well as timing of consumption of meals.

Measurement:

Weight and height was measured by the researchers. Height was measured to the nearest 0.1cm using standard calibrated scale attached to the balance against wall. Weight was measured to the nearest 0.2kg using weighting machine. During measuring body weight, participants were wearing light clothes and thin socks or bare feet, BMI was computed as body weight in (Kg) divided by body height in (m) squared and the body mass index was interpreted by comparison with CDC growth chart (weight for age and height for age) . In this study also were used food composition table for analysis of meals and few of them by USDA45 (in the case of absence of some meals in food composition table). More than 750 meals were analyzed , including more than 1000 food items to determine minerals levels (sodium ,potassium , calcium, zinc, iron , magnesium, copper, phosphorus and selenium), and compared them with FDA's RDAs. Children then were categorized into three groups that include , consumed less than the recommendation (below the RDA) , more than the recommendation (exceeds the RDA) and among the recommendation if their intake was near of recommendation.

Statistical analysis:

The Statistical Package for the Social Sciences (SPSS) version 26 was used to analyze the data. Descriptive statistical tests were conducted to make comparison including frequencies and Chi square test with (95%) confidence interval .One sample t test was used to test differences between minerals intake and recommended dietary allowance (RDA). All p values <0.05 were considered statistically significant.

Ethical statement:

This study was approved by university of Benghazi and all questionnaires were anonymous and unidentified to ensure the confidentiality of collected information. All parents or persons responsible for each participating child provided written consent for inclusion in the study.

Results

Demographical characteristics of children:

The study targeted N= 150 school age children (46% boys and 54% girls) with most distributed age range from 9-12 years. Most of children were at fourth and sixth years of their study. More than half of participants (56%) were with very good socioeconomic status (SES), and the majority of parents' children were employed (95.3% of fathers and 60.7% of mothers). Most of fathers' and mother's children had graduated level of education, 78.7% and 82.7% respectively. See table 1

***Table 1:** Demographical characteristics of school age children*

Characteristics	N	%
Sex:		
Boys	69	46%
Girls	81	54%
Age :		
5-6 years	20	13.3%
7-8years	29	19.3%
9-10years	53	35.3%
11-12 years	48	32%
School year:		
First year	21	14%
Second year	10	6.7%
Third year	23	15.3%
Fourth year	40	26.7%
Fifth year	25	16.7%
Sixth year	31	20.7%
Economic status:		
Excellent	27	18%
Very good	84	56%
Good	39	26%
Work status of father:		
Employed	143	95.3%
Unemployed	1	0.7%
Retire	1	0.7%
Passed away	5	3.3%
Work status of mother:		
Employed	91	60.7%
Housewife	59	39.3%
Father's education:		
Undergraduate	28	18.7%
Graduate	118	78.7%
Postgraduate	4	2.7%
Mother's education:		
Undergraduate	25	16.7%
Graduate	124	82.7%
Postgraduate	1	0.7%
Total	150	100

Medical and family history of children:

Regarding to medical history of children, more than half of them (54.7%) had dental disease whereas only 7.3% had bone diseases. Most of children had hypertension and diabetes in their family history with similar percentage (63.8%), and only 17.4% had family history with osteoporosis. See table 2

Table2 : Description of medical and family history of children

History	Frequency N	Percentage %
Medical history:		
Bone diseases	11	7.3%
Dental diseases	82	54.7%
Others	5	3.3%
No diseases	52	34.7%
Family history:		
Hypertension	95	63.8%
Heart diseases	44	29.7%
Diabetes	95	63.8%
Osteoporosis	26	17.4%
Kidney diseases	23	15.4%
Irritable bowel syndrome	52	35.4%
others	5	3.3%

The changes in health status and academic achievement of children:
Table 3 shows that the majority of parents 93.3% stated that the health status of their children did not change after starting school. Most of children 80% did not have changes in their attention and focusing in the class. More than half of students 66.6% had excellent level of academic achievement. There is no association between dietary minerals intake of children and their attention in class and academic achievement (p.value < 0.05) in regarding to weight changes, a round half of children 59.4% didn't have weight changes after starting school and, 22% of them had increased in their body weight.

***Table 3:** The changes in health status and academic achievement of children after starting school*

The changes	Frequency N	Percentage %
Child health changes :		
Yes	10	6.7%
No	140	93.3%
Child attention and focusing:		
Yes	30	20 %
No	120	80%
Level of academic achievement:		
Excellent	100	66.6%
Very good	35	23.4%
Good	14	9.4%
Low	1	0.6%
Child weight changes		
Yes , increased	33	22%
Yes , decreased	28	18.6%
Didn't change	89	59.4%

BMI and physical activity distribution of children:
According to body mass index (BMI) classification, this study found that less than half of school children 46% had a normal weight with similar distribution among males and females (23%) . On other hand, females as compared with males had more distribution of underweight (11%, 6% respectively). See figure 1 In addition, more than half of children 64% had active level of physical activity and only 3% of them did not have any activity in their life. See figure 2

Mineral intake among school age children
Table 5 indicates that the mean intake of calcium, potassium, magnesium, selenium , and zinc among children was significant lower than recommended dietary allowances (RDA) (1225mg, 2305mg, 245.6mcg, 141.1mg respectively). In contrast, copper, sodium , and iron intake were significant higher than RDA. (1.3mg , 2905mg , and 19mg respectively). There was no significant relation between calcium, phosphors, iron and zinc intake and their RDA, p. value < 0.05.

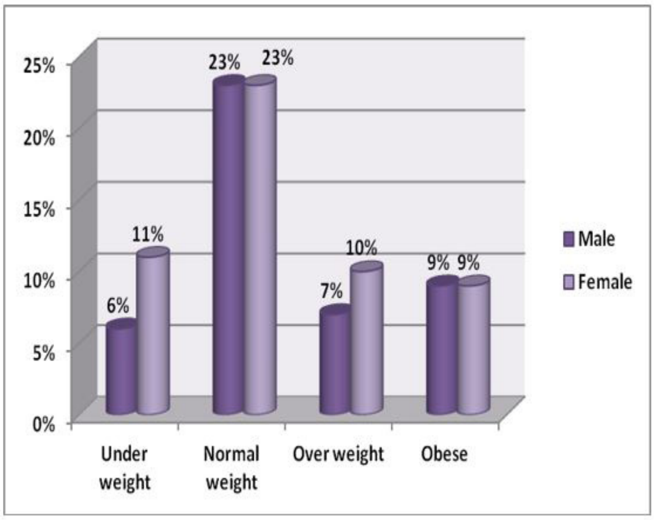

***Figure 1:** The Body Mass Index of school age children*

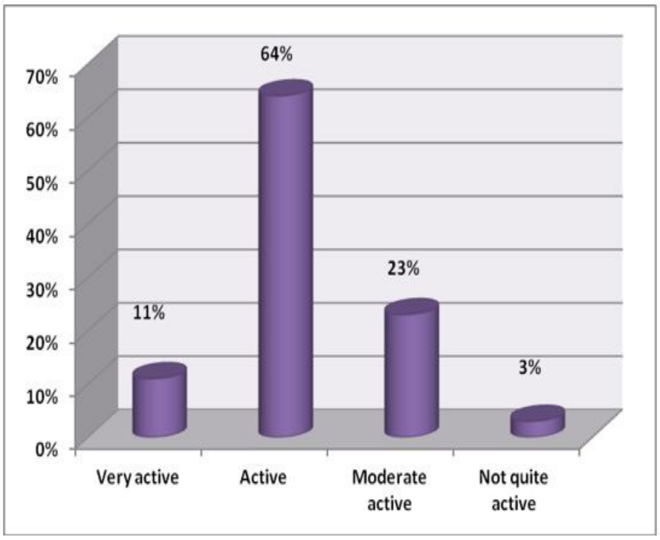

***Figure 2:** Description of physical activity among school age children*

***Table 5:** Major and micro-minerals consumption by school age children*

Minerals	Mean	Standard deviation	RDA	P.value
Calcium*mg/day	1225	±565	1300	0.000
Copper*mg/day	1.3	±1.35	0.9	0.000
Sodium *mg/day	2903	±602	2300	0.000
Potassium *mg/day	2305	±867	4700	0.000
Phosphors mg/day	1239	±534.2	1250	0.804
Magnesium* mg/day	245.6	±100	420	0.000
Iron mg/day	19	±21	18	0.295
Selenium * mcg/day	141.1	±109.6	420	0.000
Zinc mg/day	10	±19	11	0.565

(*) statistical difference p. value <0.05 by one sample T test.

The association between minerals intake and demographical factors:

This study indicated that there was association between mineral intake and gender. The female were more consumed below RDA of daily calcium, potassium , magnesium , iron and zinc intake than male (69% vs 31%,p.value=0.01, 56% vs 44%, p.value = 0.04,63% vs 37%, p.value=0.039 , 65% vs 35% ,p value=0.04, and65vs 35, p.valu=0.001). While phosphors intake was exceed RDA among male than female (56% vs 44%, p.value 0.04 respectively). Interestingly, this study found that no significant relation between sodium and gender. However, both gender had exceed RDA of sodium intake (50% , p.value = 0.394). Further association was between iron and potassium intake and economic status. The consumption of iron and potassium were below RDA among children with good economic than children with excellent economic status (26% vs 16%, p.value=0.004, 42% vs 15%, p.value=0.006 respectively).

See table 6,7

Table 6: *the association between minerals intake and sex of school age children*

Minerals intake	Sex		P.value
	Male	Female	
Daily calcium intake: *			
Exceed RDA	60%	40%	0.01
Among RDA	49%	51%	
Below RDA	31%	69%	
Daily sodium intake:			
Exceed RDA	50%	50%	
Among RDA	35%	65%	0.394
Below RDA	40%	60%	
Daily potassium intake: *			
Among RDA	77%	23%	0.04
Below RDA	44%	56%	
Daily phosphors intake: *			
Exceed RDA	56%	44%	0.04
Among RDA	41%	59%	
Below RDA	37%	63%	
Daily magnesium intake: *			
Exceed RDA	57%	43%	0.039
Among RDA	50%	50%	
Below RDA	37%	63%	
Daily iron intake: *			
Exceed RDA	54%	46%	0.04
Among RDA	49%	51%	
Below RDA	35%	65%	
Daily zinc intake: *			
Exceed RDA	71%	29%	0.001
Among RDA	39%	61%	
Below RDA	35%	65%	

(*) statistical difference p. value <0.05 by chi-square test

Table 7: *The association between iron and potassium intake and economic status of school age children*

Minerals intake	Economic status			P.value
	Excellent	Very good	Good	
Daily potassiumintake: *				
Among RDA	56%	11%	33%	0.004
Below RDA	15.6%	58.8%	25.6%	
Daily iron intake:*				
Among RDA	28%	59%	13%	0.006
Below RDA	15.4%	42.1%	42.5%	

(*) statistical difference p. value <0.05 by chi-square test

Discussion

The findings of this study revealed that most children have mainly dental caries and issues, and few of them had bone diseases. These health problems could be give indication to dietary minerals deficiency especially calcium intake. The results from other studies and surveys of this age group indicated children suffered from micronutrient imbalance (10-14,19,31,33,35,46). This is because those studies had cases with extreme imbalance issues and longer effect time. However , interventions must be conducted to prevent future health crisis that are most defiantly happening since this study found almost all parents and families of the student had severe health issues .

Unlike other studies47-50 indicated that school performance and child's attention and focus are effected by school's environment and nutrition of the child , majority of participants(66.4% and 79.7%) in this study did not show reduction in performance, focusing, attention yet, and that's due most likely to the early stage of inadequate intake and the low sample size, after a period of time , if students kept these imbalanced intakes and poor behavior it is almost guaranteed that their performance, focus, attention will get worse.

As for students overall health changes , this study results demonstrated no change in health , similar to most previous studies 51,52 which reported that schools actually either have no impact or improve the overall health of students, however that's only when schools had special nutrition related programs, and our study lacked important lab tests to ensure overall health due to information bias from participants, this study relied on the parents own point of view.

Furthermore, regarding weight changes the finding of this study, was that an appropriate percentage of the students weight had been influenced by school both gain and loss, confirming other studies 53,54 outcomes, indicating the need for intervention. Regarding students' BMI , this study found that half the students have a normal BMI for age ,with the rising numbers of both overweigh/obese and underweight of children. Similar to most studies 55-57 that concluded BMI for age of students changed throughout the years with rising numbers of both obesity and thinness. Similar to the majorities of previous studies, the current study indicated that the physical activity of children is active58.however this is according to the parents where they estimated the average time of their child's activity.

Regarding mineral intake , this study results match many other studies (59,14,15,16,25,60-63),, and surveys, where sodium and copper are being abused (with mean2903 mg/day p=0.000 <0.05) and (1.3mg/day p=0.000 <0.05) respectively. On the other hand, calcium, magnesium, potassium and selenium were neglected and under the RDA (1225mg/day ,245.6mg/day ,2305mg/day and 141mcg/day all with p=0.000 < 0.05). Therefore, public health team should plan and prioritize these issues as they are urgent.

Furthermore, this study demonstrated relationships between sex and mineral intake have been established, which are nearly identical to other studies 64-67 around this subject. For calcium, potassium ,magnesium ,iron and lastly zinc , Females participants had very low intakes compared with males. With phosphorus, males exceeded intake. Sodium is the only mineral which had same results with both sexes abusing it. This needs to be solved immediately because females already represent a risk group (with higher susceptibility towards osteoporosis, infections, and growth problems), and females must maintain good health and nutritional status as they prepare for child bearing years.

In addition, some relationships has been observed between economic (good ,very good) status and potassium and iron consumption, as those two minerals are found predominantly in expensive foods such as fruits , vegetables and animal products respectively. This outcome corresponds to other studies about SES and mineral coverage. 68-70

Conclusion and Recommendation:

The current study concluded that there was dietary mineral imbalance among school children, and females were more consumed below the RDA than males. This study found also significant association between the minerals intake among school children and socioeconomic status. Further investigation, surveys and biochemical testing must be done, for a more detailed research. Nutrition education programs targeting parents, teaching them basis of nutrition, which foods to buy, the essentials of fortified foods, reading packaged to check for high additives and sodium/phosphorus..etc. , along with teaching them how to prepare school meals and get involved as much as possible .School cafeterias should have certain policies and rules to ensure only healthy food is being served.

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