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Original Article

Dietary intake of a sample of stunted Egyptian preschool children

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Abstract

Background

Growth retardation is highly prevalent among children. Infections and inadequate food intake are well-established causes of growth retardation. Nutrition plays a key role in the control of linear growth.

Objective

The aim was to assess dietary intake of stunted Egyptian preschool children.

Participants and methods

The study was designed as a case–control study that included 100 Egyptian children aged 2 to less than 6 years old with delayed linear growth, proportionate stunting, who were randomly selected from the stunted outpatient clinic of National Nutrition Institute. Their results were compared with age-matching and sex-matching controls. All participants were subjected to the following baseline assessment: full history; clinical examination; anthropometric measurements; dietary assessment including '24-h recall and food frequency questionnaire; and laboratory investigation, including hemoglobin concentration, serum Ca, Zn, vitamin A, thyroid stimulating hormone, T4, and T3.

Results

There was a dietary intake deficiency of several micronutrients among stunted children (primarily Ca, Zn, and vitamin A) as well as all macronutrient intake.

Conclusion

Dietary deficiency of macronutrients and specific micronutrients may play an essential role in linear growth retardation among stunted children. The calcium intake level among stunted children was far below the recommended figures. Nutrition education messages encouraging adequate consumption of dairy products are needed to counteract this pattern of low calcium intake.

Keywords: Micronutrients, preschool, stunting

Introduction

Child growth is internationally recognized as an important indicator of nutritional status and health in populations. The percentage of children with a low height for age (stunting) reflects the cumulative effects of undernutrition and infections since and even before birth. This measure can therefore be interpreted as an indication of poor environmental conditions or long-term restriction of a child's growth potential. The percentage of children who have low weight for age (underweight) can reflect 'wasting' (i.e. low weight for height), indicating acute weight loss, 'stunting', or both. Thus, 'underweight' is a composite indicator and may therefore be difficult to interpret [1]. Stunting implies long-term undernutrition and poor health among young children or environmental problems, endocrinopathy, or chronic disease [2]. Stunting is a standard marker of failure in early growth. Stunting is associated with delayed mental

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development, poor educational achievement, and reduced intellectual capacity. It is a strong predictor of human capital and social progress [3]. Egyptian demographic and survival indicators have shown marked improvement in life expectancy and under-5 mortality. Despite these improvements in health conditions, there are still important impediments to the linear growth of children [4]. In terms of macronutrient deficiencies, around one in five children under the age of five are classified as stunted and one in ten are classified as severely stunted [5]. Nutrition plays a key role in the control of linear growth. Inadequate nutrition leads to diminished cartilaginous growth and osteoplastic activity; insufficient protein intake with resultant negative nitrogen balance interferes with the deposition of organic material in bone [6]. The growth and development of the human skeleton require an adequate supply of many different nutritional factors, macronutrients and micronutrients [7]. Macronutrients play an important role in linear growth. Protein consumption has an anabolic effect on cell growth and increases bone formation [8]. During periods of rapid growth, extra energy per unit of body weight is necessary to build new tissue. In childhood, the most rapid growth occurs during infancy and adolescence, with continuous but slower growth in-between [9]. Micronutrients are essential for linear growth. Calcium is important for the structure of bones and teeth, blood clotting, nerve and muscle function, and energy metabolism [10]. Different factors affect calcium levels like excess sodium and protein intake. Excess sodium raises calcium excretion, presumably because sodium competes with calcium for reabsorption in the renal tubules. Excess animal protein also increases urinary losses of calcium [11]. Phosphorus is present in every cell membrane, and phosphate ions associate with calcium ions to form hydroxyapatite, the major inorganic molecule in teeth and bones, as reported by Caulfield *et al*. [12]. Magnesium is essential for the maintenance of healthy bones. Approximately half of the magnesium in the body is found in bones [13]. The effects of severe magnesium depletion on bone metabolism include decreased PTH secretion, impaired responsiveness of bone, and impaired bone growth [14]. Zinc is essential for growth, and its deficiency results in growth failure. Zinc is also essential for the activity of enzymes in osteoblasts that are responsible for collagen synthesis [15]. Improving zinc nutrition status by food and supplementation programs has demonstrated positive results in a population with high rates of childhood stunting [16]. Iron serves as a catalytic cofactor for the vitamin C-dependent hydroxylation of proline and lysine in collagen maturation, and iron also has additional roles in osteoblast activity [17]. Iron associated with the electron transport chain is involved in ATP production. Iron deficiency can cause fatigue, decreased work performance, and impaired intellectual abilities, as reported by Stoltzfus *et al.* [18]. Iodine is a component of the thyroid hormones, which are important for growth, development, brain function, and energy metabolism, as reported by Caulfield *et al.* [12]. Thyroid hormone is necessary for bone growth because of both indirect effect on the GH-IGF axis and direct effects on bone growth. physiological levels of circulating thyroid hormones are necessary to maintain normal pituitary GH secretion owing to their direct stimulatory actions. [19]. Vitamins are other micronutrients that play a paramount role in bone growth. Vitamin A and the carotenoids are important in the regulation of growth, reproduction, vision, immune function, gene expression, and bone formation. Vitamin A is required for healthy bones [20]. Adequate vitamin D intake is important for bone formation, growth, and repair. The major importance of vitamin D for bone is to facilitate the absorption of calcium from the diet. The influence of vitamin D on bone mineralization is particularly important in children [21]. Vitamin C easily loses electrons and is reversibly converted to dehydroascorbic acid; it serves as a biochemical redox system involved in many electron transport reactions, including those involved in the synthesis of collagen and carnitine and other metabolic reactions. Vitamin C acts as a reducing agent to keep iron in its ferrous state, thus enabling hydroxylation enzymes to function [22]. vitamin K as a multifunctional vitamin has been recently deemed appreciable as a topic of research as it plays a pivotal role in maintenance of the bone strength, and it has been proved to have a positive impact on the bone metabolism. Vitamin K exerts its anabolic effect on the bone turnover in different ways. [23]. The present study was carried out to clarify the adequacy of the role of macronutrient and micronutrient intake of stunted preschool children.

Participants and methods

A case–control study was conducted on 100 preschool children aged 2 to less than 6 years, with delayed linear growth, proportionate stunting, determined by height for age less than −2SD of references standard child growth curves (according to the WHO [1]), attending the stunted outpatient clinic of the National Nutrition Institute (NNI). They are chosen by a random technique. Moreover, 50 age-matched control group children with normal linear growth were included as well. The selection was made according to the inclusion and exclusion criteria as follows: Children with proportionate stunting owing to nutritional deficiency and other causes such as hormonal, bone diseases, celiac diseases, or any metabolic conditions, are excluded. All cases, as well as controls, were subjected to assessment of the nutritional status:

(1) All children stunted group, and their control was subjected to clinical evaluation of nutritional status, as well as general and systemic examination
(2) Anthropometric measurements included height, weight, and BMI.

Height

The height was measured using the Raven Minimeter, with direct reading of height, it was on the floor with the back resting against the upright surface to which the Minimeter is fixed. The following categories of height status were determined

according to the WHO [1]:
(1) Stunting less than −2SD.
(2) Normal –2 to +2SD.
(3) Tall: more than +2SD.

Weight

The weight was recorded using a platform scale; the scale was standardized by known weight before the survey in each studied site and corrected according to the test. Corrections were done according to reading and were done to the nearest gm [1].

Assessment of weight and height for age (BMI): for age from 2 to less than 6 old, the percentile BMI was used for males and females. The following categories of weight status were determined according to the WHO [1]:
(1) Underweight: less than 5 percentile.
(2) Normal weight: 5^{th} to less than 85^{th} percentile.
(3) Overweight: 85^{th} to less than 95 percentile.
(4) Obese: more than 95^{th} percentile.

Dietary assessment

Methods used for measuring food consumption of studied groups were classified into two major groups. The first group, known as quantitative daily consumption method, consisted of recalls or records designed to measure the quantity of food items consumed over one-day period, '24-h recall' method. The second method included the dietary pattern; for the children, quantities of food consumed were estimated in household measures and grams. The obtained dietary information included a detailed description of all food consumed including cooking method, and the amount of each ingredient in the recipe was recorded. The conversion of household measures to grams was achieved through the use of a prepared list of weight of commonly used household measures in Egypt developed by 'the NNI of Egypt and Food Standards Australia and New Zealand [24,25].' The compiled food composition tables of the 'Michelle Mcquire and KA Beerman and the NNI of Egypt [24]' were used to determine the energy and nutrient intake of each individual. Adequacy of the diet consumed was assessed by comparing the energy and nutrient intakes of the person with the recommended dietary allowances (RDA) [26]. Computerized analysis was based on energy, protein, fat, carbohydrates, copper, calcium, magnesium, selenium, zinc, iron, iodine, phosphorus, thiamin, riboflavin, vitamin A, vitamin C, and niacin percentage of %RDA.

Laboratory investigations

Laboratory profile was done at the NNI laboratory for subsample of cases and their controls.

Blood samples were collected from the included preschool children. The serum was separated by centrifugation (3000 rpm 10 min). Separated serum was stored frozen at −70°C until analysis for the following:
(1) Hemoglobin: determination of hemoglobin was done by the colorimetric method. Children 2–6 years had a cutoff point of 11–14 g/dl, according to Drabkin [27].
(2) Calcium: Determination of calcium was done from serum. Cut off point was 10–12 mg/dl according to Kaplan and Pesce [28].
(3) Serum zinc: cutoff point was 60–110 g/dl, according to Johsen [29].
(4) Serum vitamin A: according 130 to 600 mg/L Bieri *et al*. [30] cutoff point.
(5) DS-EIA-thyroid-thyroid stimulating hormone (TSH): cutoff point was 0.4–7 l/ml, according to Fisher [31].
(6) FT4: cutoff point was 7–22 pg/ml, according to McComb *et al*. [32].
(7) FT3: cutoff point was 1.2–4.2 pg/ml, according to Wild [33].

Results

The sample of the present study included 150 children, comprising 100 stunted cases and 50 children as controls. Stunted cases represent 61 boys and 39 girls. Controls represent 29 boys and 21 girls.

Table (1) shows that the mean height of the stunted boys & girls was compared to for the control group with highly significant difference between the two groups (p=0.000). To assess the nutritional status of children, Height/Age (Z score was used) (WHO 2006). Mean height for age Z score among the studied stunted boys and girls was (-1.76±1.77 and-1.71± 1.81). While mean height for age among the studied control children was (-0.67±0.98 and -0.2±o.96) respectively.

Table 2 and Fig. 1 indicated the mean mineral intakes and their percentage from RDA. Practically, it was proved that minerals (calcium, zinc, selenium, and magnesium) revealed a decrease in the mean values of intake in comparison with RDA. These differences in mineral intake between stunting children and the control group were with a significant difference, whereas the intake of the mineral above RDA was shown in iron, copper, iodine, and phosphorus among both stunted and control groups, with significant difference, except for copper intake in the two groups, which showed no significance (Table 3).

Concerning relative mean intakes of some vitamins and their percentage from RDA, as shown in Table 4 and Fig. 2, niacin and vitamin A intakes were decreased from RDA among stunted and the control group, with a significant difference. Although the mean and percentage of vitamins intake were comparable with RDA among the studied children, excessive sample intake was seen in thiamin, riboflavin, and vitamin C about RDA in both groups, but there were significant differences, except for thiamin.

Table 4 and Fig. 3 asserted that mean energy intake among studied stunted children was 927.35 kcal, which represents 74.19% from RDA for energy, and 1265.4 kcal for the control group, which represents 101.2% from RDA for energy, with significance difference ($P = 0.000$). Regarding energy, it can be found that the mean values of protein, fat, and carbohydrates

Table 1: Mean anthropometric measurements of the studied children by sex

Sex	Anthropometric measurements	Cases (mean SD)	Controls (mean±SD)	*P*
Boys	Height	91.9±8.2	98.7±7.13	0 .000***
	Height/age *Z* score	−1.76±1.77	−0.67±0.98	0 .000***
	Weight/height *Z#* score	−0.05±1.25	−0.77±1.16	0 .005**
Girls	Height	90.05±7.3	101.68±9.4	0 .000***
	Height/age *Z* score	−1.71±1.81	−0.2±0.96	0 .000***
	Weight/height *Z#* score	−0.19±1.18	−0.99±2.79	0 .005**

*p < 0.05 **p <0.01 ***p <0.001 NS = Not Significant

Table 2: Mean and percentage of mineral intakes in relation to RDA of the studied children

Minerals	Cases (mean±SD)		Controls (mean±SD)	*P*
Calcium (mg) intake	314.6±145.3		559.10±256	0.000***
RDA for Ca.(mg/d)		500-600		
%intake from RDA	57.2		101.7	
Total iron (mg) intake	9.08±3.6)		7.87±3.28)	0.04*
RDA for iron (mg/day)		6		
%intake from RDA	131.2		151.3	
Total zinc (mg) intake	4.71±1.74		5.94±2.62	0.001**
RDA for zinc (mg/day)		4.1-5.1		
%intake from RDA	94.15		118.72	
Copper (μg) intake	535.7±227.7		611.5±276.3	0.08 (NS)
RDA for Cu (μg/day)		340-440		
%intake from RDA	137.4		156.8	
Selenium (μg) intake	23.57±7.9		30.5±13.2	0.000***
RDA for Se (μg/day)		20-30		
%intake from RDA	94.3		121.9	
Iodine (g) intake	114.82±44.51		168.37±93.75	0.000***
RDA for iodine (g/day)		75-110		
%intake from RDA	127.58		187.08	
Phosphorus (mg) intake	489.3±147.2		659.6±233.8	0.000***
RDA for P (mg/day)		460-500		
%intake from RDA	102		137.4	
Magnesium (mg) intake	58.9±20.4		102.3±36.7	0.000***
RDA for Mg (mg/day)		60-75		
%intake from RDA	78.7		153.8	

RDA, recommended dietary allowance. Deficiency Surplus.

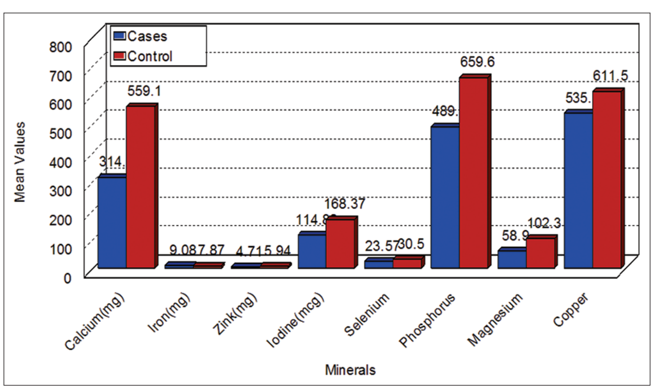

Figure 1: Mean of minerals intakes of children in the studied sample (cases and controls).

were less than RDA among stunted children. These values revealed significant differences among stunted children and the control group.

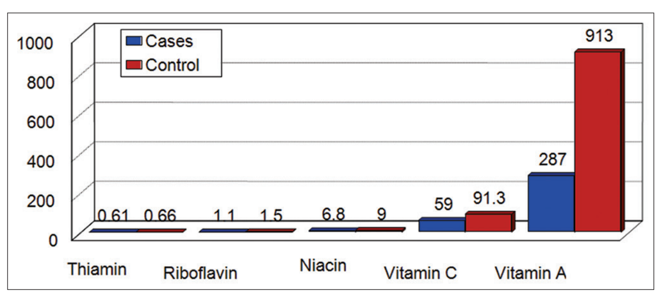

Figure 2: Mean intakes of some vitamins of the studied children (cases and controls).

Table 5 shows the means of some laboratory parameters among studied children. The mean hemoglobin was 9.90 and 10.24 g among stunted children and the control group, respectively, with no significant difference. Other parameters, such as albumin, TSH, T3, T4, Ca, Zn, and vitamin A of stunted children and control group, were significantly different,

Table 3: Mean and percentage of some vitamin intake in relation to RDA of the studied children

Vitamins	Cases (mean±SD)		Controls (mean±SD)	*P*
Thiamine (mg) intake	0.61±0.25		0.66±0.25	0.27 (NS)
RDA for thiamine (mg/day)		0.5-0.6		
%intake from RDA	111.7		120.4	
Riboflavin (mg) intake	1.1±0.79		1.5±0.8	0.009**
RDA for riboflavin (mg/day)		0.5-0.6		
%intake from RDA	201.5		267	
Niacin (mg) intake	6.8±2.8		9.0±4.1	0.000***
RDA for niacin (mg/day)		6-8		
%intake from RDA	97		129	
Vitamin C (mg) intake	59±67.9		91.3±87.5	0.04*
RDA for vitamin C (mg/day)		30		
%intake from RDA	196.8		291.5	
Vitamin A (g) intake	286.8±129.9		913.48±718.9	0.000***
RDA for vitamin A (g/day)		400-450		
%intake from RDA	67.5		214.0	

RDA, recommended dietary allowance. Source: RDA for Ca, Mg, Zn, Fe, iodine, and vitamins (FAO/WHO, 2002), RDA for Cu, P, Se, Carbohydrates, and fat (Mahan and Sylvia, 2008).

Table 4: Mean and percentage of macronutrient intakes in relation to RDA of the studied children

Macronutrients	Cases (mean±SD)		Controls (mean±SD)	*P*
Energy (kcal) intake	927.35±276.5		1265.4±332.8	0.000***
RDA for energy (kcal/day)		1047-1467		
% intake from RDA	74.19		101.2	
Total protein (g) intake	36.03±10.83		47.01±16.51	0.000***
RDA for protein (g/day)		13-37		
% intake from RDA	96.09		125.37	
Total fat (g) intake	25.04±10.43		38.09±18.84	0.000***
RDA for fat (g/day)		30		
% intake from RDA	83.48		126.97	
Carbohydrates (g) intake	114.0±11.3		144.38±54.75	0.000***
RDA for carbohydrates (g/d)		130		
% intake from RDA	87.7		111.1	

RDA, recommended dietary allowance. Source: RDA for energy (FAO/WHO/ UNU, 2004).

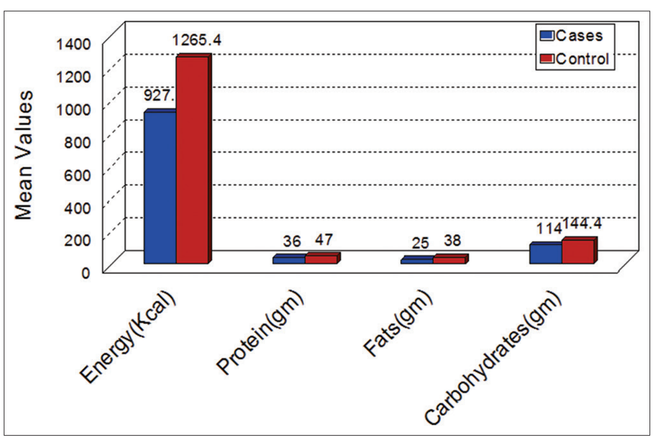

Figure 3: Mean of macronutrient intakes of the studied children (cases and controls).

although albumin, TSH, T3, and vitamin A values were within the normal level in both groups. Calcium and T4 value were less than the cutoff point among stunted children and the control group, with a significant difference.

Discussion

Nutritional status is a primary determinant of a child's health and well-being. Anthropometric measurement is a practical and immediately applicable technique for assessing children's development patterns during the first 5 years of life, as reported by Biswas *et al.* [34]. The height for age index provides an indicator of linear growth. The present study showed that the weight and the weight/height for stunted children were low compared with the control group, with a significant difference, especially among girls. The 2008 EDHS found that 29%of Egyptian children age 0–4 years showed evidence of chronic malnutrition or stunting. A comparison of the results with the 2005 EDHS suggested that children's nutritional status deteriorated during the period between the two surveys. The stunting level increased by 26% between the two surveys [35]. The present result was consistent with other low-income and middle-income countries in the Asian region. For example, prevalence is similar in magnitude to rates in middle-income Asian countries, including Vietnam (23%; General Statistics Office of Vietnam, 2011) and Tajikistan (27%; UNICEF,

Table 5: Mean of some laboratory parameters among the studied children

Age	Parameters	Cut off point	Cases (mean±SD)	Controls (mean±SD)	*P**
2<6	Hb	1114 g/dl	9.90±0.82	10.2±40.61	0.101 (NS)
	Albumin	3.85.1 g/dl	4.27±0.43	5.0±0.32	0.0002***
	TSH	0.47lu/ml	2.36±0.77	2.79±0.64	0.003**
	T3	1.24.2 pg/ml	3.03±1.01	4.07±1.39	0.0003***
	T4	722 pg/ml	4.17±1.89	5.22±1.14	0.0003***
	Ca	1012 mg/dl	8.49±1.84	9.66±1.26	0.0008**
	Zn	60 110 g/dl	94.11±32.77	140.83±58.17	0.0009**
	Vitamin A	361 20 g/dl	43.71±17.99	63.45±11.94	0.003**

Hb, hemoglobin; TSH, thyroid stimulating hormone.

2016), while remaining moderate for South Asia, following Sri Lanka (15%), but lower than an overall prevalence of stunting of ~37% among young children in neighboring Bangladesh, India, and Nepal. This result was in accordance with the Indian study by Biswas et al. [34] who reported significant differences existed in mean height in the preschool children. The growth and development of the human skeleton require an adequate supply of many different nutritional factors, minerals, and vitamins [7]. The present study highlights micronutrients and macronutrients consumption among stunted preschool children. Regarding mineral consumption, calcium was the lowest mineral intake in relation to % RDA among stunted (57.2%) compared with 101.7% for the control, followed by magnesium (78.7 and 153.8%, respectively), zinc (94.15 and 118.72%, respectively) and selenium (94.3 and 121.9%, respectively), whereas cupper, iron, iodine, and phosphorus intakes were higher than % RDA for both the stunted and control groups. Regarding calcium and phosphors intake, our result was in line with a Kenyan study by Emily Bloss [36], who reported low intake of calcium among stunted preschool boys and girls, which was lower than the RDA. In a study in Tehran, Ca intake was significantly lower in the shorter preschool children [37]. Our study showed that iron intake was higher than % RDA. The result was in line with the Nigerian study by Ejas., which reported increased intake of iron in stunted studied group diets, probably because they consumed a more diverse group of cereals, most of which contained more iron. The finding was, in contrast, to the study carried on Bedouin preschool children in Jordon that recorded low iron intake (25.2%) and presence of anemia (57.3%) among them [38]. In spite of the relative adequate iron intake in our study, laboratory results represented by the mean hemoglobin was 9.90 and 10.24 g among stunted children and control group, respectively, with no significant difference. These confrontations could be explained by low intake of animal protein, which may result in reduced bioavailability of iron [39]. Moreover, this could be explained by inadequate absorption owing to presence of inhibitors such as phytate and polyphenols in plant-based foods, which are the most cited inhibitors of iron [40]. Zinc is an essential micronutrient for growth and proper immune function. Our result revealed a low intake of zinc among the stunted group compared with the control group. Similar results were reported by Imdad [41]. Zinc intake was low among cases and control groups (94.15 and 118.72, respectively) Compared to the RDA %. Another supportive evidence found that more than 25% of stunted children had inadequate zinc intake. Iodine intake was high among stunted and control groups in the present study (127 and 187%, respectively) of RDA. This result could be explained by application of iodized salt programs in our country, which decrease iodine deficiency. This success resulted in enthusiastic political and financial support for increased global coverage, and control of IDD [12]. Regarding vitamins intake, the present study showed that the percentage of children meeting the RDA of vitamin C intake was higher. This result reflects the food pattern in our country and adequate dietary intake of vitamin C-rich fruit and vegetables. The study finding was in contrast to another study in Kenya which record reduced intake of vitamin C, which explained their food pattern, where grain wheat maize was the main diet with reduced intake in the form of vitamin C-rich fruit and vegetables, predominantly in rural areas of low-income countries, where the diet is based on cereal staples [36]. Macronutrient intake asserted that mean energy intake among studied stunted children was represent as 74.19% from RDA for energy. The control group represents 101.2% from RDA for energy, with a significant difference. It was found that the mean intakes of protein, fat, and carbohydrates were less than RDA among stunted children. Ibrahim and his colleagues made similar conclusions that deficiency of several nutrients, including energy and proteins, is seen in stunted children, and the combined effect of these deficiencies might have a role in the retardation of growth in height. A Tehran study in 2013 found that adherence to dietary patterns high in protein might be associated with reduced odds of being stunted among children. Regarding the mean of some laboratory parameters among studied children, the mean TSH, T3, T4, zinc, and vitamin A were within normal levels among stunted children; they were less than the control group with a significant difference. Supportive evidence of our result came from Hussien, a study in Ethiopia.; his work provided results that there was a high level of anemia and stunting among children. Our result was in line with Ejaz and Latif [42]. They found that anemia was the most common micronutrient deficiency seen in 78% of patients. Of these, 88% had iron-deficiency anemia, and calcium deficiency was found in 54 (36%) patients. Vitamin A deficiency was present in

14% of cases. Other miscellaneous micronutrient deficiencies were zinc (28%). In conclusion, among the studied Egyptian children, stunted children experience more negative effects that have profound effects on the development of linear growth. It seems that dietary intake deficiency of several micronutrients of stunted children (primarily Ca, Zn, Mg, and vitamin A) and all macronutrients play important roles in their linear growth retardation. The calcium intake level among stunted children is far below the recommended figures. Nutrition education messages encouraging high consumption of dairy products are needed to counteract this pattern of low calcium intake. Preventive strategies to prevent stunting and promote healthy eating and milk consumption are recommended.

Recommendation

Based on the results, we provide the following recommendations:

(1) Increase and sustain budget allocation to strategies addressing stunting: there is a need for the government of Egypt to guarantee long-term funding for these strategies rather than the interventions being donor-driven.

(2) Accelerate current efforts to monitor stunting: routine measurement of height at the health facility level and analysis and decision making at sub-national (district and county) level need to be accelerated.

(3) Spreading nutritious awareness and planting intact nutritious behaviors and acquiring intact nutritious habits through programs directed to the family through all means of mass media.

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Conflicts of interest

There are no conflicts of interest.

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