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Effect of a 2-Month Program of Antioxidants-Micronutrient-Rich Diet on Concentrations of Lead, Cadmium and Aluminum in Obese Egyptian Children

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Abstract

Background: It is conceivable that toxic metals contribute to obesity by influencing various aspects of metabolism. On the same time, antioxidant micro nutrient rich diet can be a major factor in chelating heavy metals.

Objective: Evaluate the effects of a 2-month program of a balanced low-caloric diet rich in antioxidants and micronutrients on the level of lead, cadmium and aluminum in obese children.

Materials and Methods: 65 children (11 to 14 years) with simple obesity (BMI > the 95th percentile) were selected in this study. Children were put on a balanced diet regimen high in antioxidants and micro nutrients with low calories (1500 cal/day) for 2 months. Levels of lead, cadmium and aluminum in 24-hour urine collected were measured before and after the intervention using atomic absorption spectrometry.

Results: Comparing before and after dietary intervention program, significant reduction was observed only in case of urinary lead and cadmium with $P < 0.001$. In addition to significant weight loss and reduction of BMI (kg/m^2) from 29.1 to 27 with $P<0.05$.

Conclusion: Diet rich in antioxidants and micro nutrients could reduce the toxic effects of heavy metals in obese children and thus facilitate control of obesity.

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Key words: Antioxidant; diet; heavy metals; micro nutrients; obesity.

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Introduction

The World Health Organization estimates that by 2015 the number of overweight people worldwide will increase to 2.3 billion, while more than 700 million will be obese [1]. Obesity in general is the result of overeating and lack of physical activity on a background of genetic predisposition. However, there is still uncertainty related to the etiology of obesity. Data suggesting a role for toxicology was supported by Baillei-Hamilton in 2002 [2]. His review showed that the current epidemic in obesity could not be explained solely by alterations in food intake and/or decrease in exercise and that the genetic predisposition factor could not be easily blamed as it does not be changed over a few decades.

Environmental changes including chemicals have been considered as partially responsible for the current obesity epidemic. Chemicals appear to cause weight gain through interfering with body weight control system; they can alter weight-controlling hormones, sensitivity to neurotransmitters, or activity of the sympathetic nervous system. Heavy metals such as mercury, lead and cadmium have no known vital or beneficial effect, and their accumulation over time in the body can cause serious illness. Ingestion of heavy metals produces renal failure and liver damage [3, 4]. Synthetic chemicals such as heavy metals, solvents, polychlorinated biphenols and organophosphates, used at nontoxic doses, induce weight gain in animals [5].

Lead, cadmium and aluminum are considered among the most deleterious health polluting metals. Lead pollution causes reduced IQ [6], learning disabilities [7], stunted growth [8], impaired hearing and kidney damage. It has been also associated with criminal behavior [9]. Cadmium, even in small amounts, damages kidneys and gastrointestinal tract and causes mild anemia and osteoporosis [10]. Chronic exposure to small amounts of cadmium can produce hypertension, coronary artery disease and emphysema [11]. When serum aluminum exceeds 10 micrograms per liter, the memory and power to concentrate diminish [12]. A geographical relationship between Alzheimer's disease and aluminum in drinking water from environmental pollution was reported [13].

Pollution impact can be reduced by increased antioxidant micronutrients consumption [14], which comes largely from fruit and vegetables [15]. This prospective study aims to evaluate the effects of a 2-month program of a balanced low-caloric diet rich in proteins, fresh vegetables, fruits and milk on the concentration level of lead, cadmium and aluminum in obese children.

Material and Methods

The study included 65 children with simple obesity; age ranged from 11 to 14 years old, most of them from low-middle social and economic classes. They were visiting the children obesity clinic at the National Research Centre. Children were excluded if they had any hormonal disorder (e.g. hypothyroidism and Cushing's disease) or were on medications that influence body composition (e.g. Insulin and Cortisone). The children were subjected to full clinical examination and laboratory tests. Parents were informed with the purpose of the study and consents were obtained.

Body weight was measured to the nearest 0.5 kg while the child was wearing light clothing and no shoes, using a standard clinical balance. Height was measured to the nearest 0.1 cm by using a wall-mounted stadiometer while the child standing with no shoes. The BMI (weight in kilograms / height in square meters) was reported. The children included in this study, were suffering from obesity based on BMI greater than the 95th percentile for age and gender based on the Egyptian Growth Reference Charts [16].

Nutritional intervention

A 24-hour dietary recall sheet was taken to analyze the children habitual dietary pattern and nutritional intake. The children were consuming fast food and street food in large amounts. Their diet included large amounts of carbohydrates, sugar and fat and little quantities of meat, milk, vegetables and fruits. The mean caloric daily intake ranged between 3000 and 4000 calories. Table 1 demonstrates their usual food composition. Children were put on a balanced diet regimen high in fruits, vegetables, milk and protein and low in calories. The selected diet supplies the daily requirements of essential nutrients, antioxidants and micronutrients according to the University of Pennsylvania Health System Food Pyramid [17]. Diet supplies 1500 calories/day. It included 6 servings of carbohydrates, 4 servings of fruits, 4 servings of vegetables, 3 servings of meat or eggs, 3 servings of milk or other diary food, 2 servings of fat or oil. Health education and support were given to children and their mothers to insure following the dietary program. Body weight was weekly reported for 2 months. Thirty girls strictly continued with the program for the 2 months.

Table 1: Food items intake and servings before and during the dietary modulating regimen.

	Dietary intake before modulation	Dietary composition during the 2-month program
Total calories intake (k.cal/day)	3000-4000	1500
Fat intake (45 calorie/ serving) (as 1 table spoon vegetable oil)	15-20	2
Carbohydrates (80 calorie/ serving) (as a slice of whole wheat bread-1/2 cup of cooked rice-1/2 cup of pasta)	15-23	6
Protein (90 calorie/ serving) (as 1 small steak meat- 1 small chicken breast half-1 can of tuna -1/4 cup of cooked bean)	1	2-3
Milk (90 calorie/ serving) (as 1 cup skimmed milk- 1 cup yoghurt fat free- 2 cups cottage cheese)	0-1	2-3
Vegetables (25 calorie/ serving) (as 1 cup cooked vegetables– 2 cups row vegetables as carrots – broccoli-spinach…..)	0-1	3-4
Fruits (60 calorie / serving) (as 1 small apple- orange- 1 cup of strawberry)	0-1	3-4

Laboratory tests

The levels of lead, cadmium and aluminum in urine (micrograms/ liter) before the dietary intervention program were assessed. The 24-hour urine was collected, 7 ml were put in a 10 ml sterile polyethylene tube washed with chromic acid over night and washed with distilled water prior to use. Two drops of 30% concentrated HCL were added to each tube. The samples were kept in deep freezer under -20^{0}C, until all samples were collected. Lead, cadmium and aluminum determination was carried out using specter AA220 atomic absorption spectrometry (Varian, Australia). Urine samples were measured using graphite furnace atomic absorption spectrometry at 217, 228.8 and 309.3 nm for lead, cadmium and aluminum respectively [18]. After 2 months another urine sample was collected and the levels of lead, cadmium and aluminum were measured.

Statistical Analysis

All values are reported as the mean ± SD (the range). Statistical evaluation of the results was performed with the SPSS 7.5 computer program. The changes in the measured parameters before and after the dietary program were calculated. Paired-*t test* was used to examine the differences before and after the dietary program. The level of significance was set at a probability of less than 5% (P<0.05).

The protocol of this study has been approved by the ethical committee of the National Research Center.

Results

Comparing the mean levels of lead, cadmium and aluminum in urine before and after the dietary intervention program, significant reduction was observed in case of lead and cadmium with P < 0.001, while for aluminum the reduction was not significant (Table 2 and Fig. 1, 2, 3).

Table 2: Mean values of heavy metal concentrations in urine in microgram per Liter before and after dietary intervention.

	Before dietary intervention	After dietary intervention	P-value
Lead	47.2(6.5)	38(6.9)	<0.001
Cadmium	12.8(1.4)	9.4(1.2)	<0.001
Aluminum	9.8(1.5)	9.6(1.6)	NS

Mean (SD), NS means non-significant.

In addition the used diet intervention resulted in significant weight loss and reduction of BMI (kg/m^2) from 29.1 to 27 with P<0.05

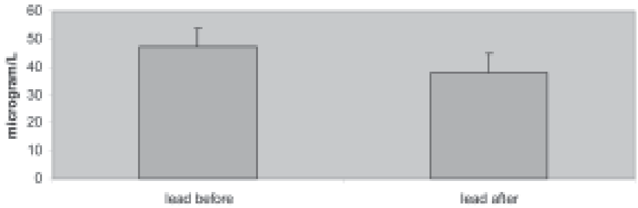

Figure 1: Lead concentration (mean ± SD) in urine (microgram/L) before and after dietary intervention (P<0.001).

Discussion

Researches in obesity have abundantly studied the relation of energy intake and major nutrients levels , but few articles reported the relation between mineral accumulation and obesity [19-22].

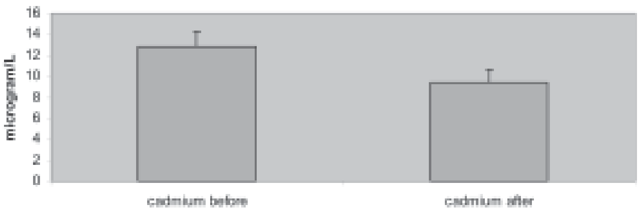

Figure 2: Cadmium concentration (mean ± SD) in urine (microgram/L) before and after dietary intervention (P<0.001).

Minerals are important in enzyme action, electrolyte balance, nerve impulse transmission, muscle contraction, bone formation, and growth and development. Essential minerals imbalance or excess of toxic minerals can cause metabolic disorders and diseases [23]; the degree of mineral accumulation in the body is a useful index as a diagnostic tool for clinical nutrition and disease state [24]. Mineral levels are

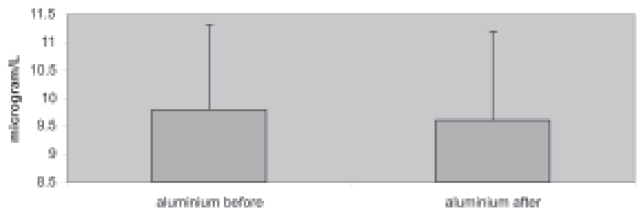

Figure 3: Aluminium concentration (mean ± SD) in urine (microgram/L) before and after dietary intervention.

measurable in tissues such as liver and hair and body fluids such as urine [23, 25]. Mineral imbalance can be caused by many factors including dietary factors, genetic disposition, beverages, and stress, aluminum cans, cooking utensils, contact with chemicals, shampoo, or residential or working environment [26].

This study revealed that children habitually like to consume fast and street food and little quantities of fresh vegetables and fruits. Fresh vegetables & fruits represent the natural nutritional sources for protection against heavy metals absorption and intoxication. Also, high levels of lead, cadmium and aluminum in urine were detected before the dietary intervention program. The used program of balanced low- caloric diet rich in protein, fresh vegetables, fruits and milk for two months resulted in a significant decrease in levels of lead and cadmium while the decrease in aluminum level was not significant.

Lead is a prime environmental pollutant and multi organ poison, in addition to its toxic effects it depresses the immune status [27]. Lead and lead compounds can adversely affect human health through either direct inhalation or ingestion of lead-contaminated soil, dust, or paint. In congested urban areas, exhaust fumes from vehicles using leaded gasoline typically accounted for 90 percent of airborne lead pollution [28]. In Egypt, it is not only the urban where auto exhaust plays the role to spread lead in atmosphere; in Cairo the same happens and additional pollution results from lead smelting industry. Unleaded gasoline has been used only in Cairo since 1999 [29]. Cars markedly have increased over the past few years. Another source of lead in Cairo may be due to the re-suspension of street dust (lead bearing dust) by the wind, vehicles motion and anthropogenic activities. The concentration of lead in the street dust of the traffic areas was found higher than that of the industrial areas [30].

The center for disease control and prevention (CDC) [31] has set a level of concern at 10 μg/dl, but recent researches telling us now that there is no level of lead exposure that can be considered safe. Lead is confirmed neurotoxin, research suggests, there is no safe exposure to lead and children's intellectual functioning is impaired by blood lead concentration, below 10 μg/dl [32, 33], so blood lead levels in children should be reduced below the levels so far considerable acceptable [34].

Regions with the highest levels of lead and other environmental pollutants typically have been shown to have crime rates three times the national average; pollution has been described as an effective factor as poverty [35]. The mechanism for this appears to be that when neurochemical processes are altered by exposure to neurotoxic metals such as lead and mercury; natural violent tendencies may no longer be inhibited. Lead partly incapacitates glial cells, which are responsible for cleaning up (house keeping) undesirable chemicals in the brain [36]. Environmental pollutants inhibit the uptake of neuro transmitters serotonin and dopamine in parts of the brain. This suggests that optimum levels of micronutrient antioxidant may have a preventive role as well as a modulating role in this environmentally induced neurodegenerative disorder [37, 38].

Micronutrients interact with toxic metals at several points in the body: absorption and excretion of toxic metals transport of metals in the body binding to target proteins metabolism and sequestration of toxic metals and finally, in secondary mechanisms of toxicity such as oxidative stress. Therefore, people eating a diet deficient in micronutrients will be predisposed to toxicity from nonessential metals [37].

Cadmium concentration in urine is considered to be more reflective of body burden in currently-exposed workers than cadmium in blood, and is the most widely used biological measure of chronic exposure to cadmium. Cadmium in urine increases with age, cigarette smoking, and exposures in the general and occupational environments. Increased use of chemical fertilizers can also lead to an increase in heavy metals such as Cd, Pb, Cu, and Zn in soils and plants [39]. Kidney damage (proteinuria and azotemia), anemia, liver injury (jaundice), and chronic obstructive pulmonary disease result from long-term exposure to cadmium by inhalation.

Heavy metals occur in many fertilizers and in some pesticides. Heavy metals may be of particular concern in tree fruit production because of the use of spray, which deposits fertilizer and pesticide residue directly on to fruits [40].

Foods, products, and over-the-counter drugs that contain aluminum, such as baking powder, antacids, and deodorants/antiperspirants are among causes blamed for aluminum intoxication. Cooking utensils with aluminum (pots and pans), wrapping sandwiches using aluminum foil and drinking from aluminum soda cans are considered a major source for aluminum overload.

Reports on Egyptian children especially in urban areas who wrap sandwiches in newspapers, are young and walk long distances to school reveal high blood lead levels [41]. School children living in polluted areas have low IQ score, poor scholastic achievement and behavior problems. Correcting the iron deficiency and calcium supplementation in children at risk of lead exposure is a protective strategy against lead toxicity [42, 43].

The children in this study most of them were from low-middle social class. Social inequality as a result of economic insecurity is also considered as one of the probable causes of obesity. A review in 2009 by Drewnowski [44] indicates that inequitable access to healthy foods as determined by socioeconomic factors could influence the diet and health of a population. Energy-dense and nutrient-poor foods become the best way to provide daily calories at an affordable cost. Lack of accessibility of healthy food choices [45] and the commercial driven food market environment [46] are considered as probable predominant causes of obesity.

Health education is needed to alter the food environment. Restriction on marketing and advertising bans of unhealthy foods has been recommended [47-49]. Studies have demonstrated that food prices have a marked influence on food-buying behavior [50]. A study designed to look at the effects of health education and pricing on the consumption of vending machine snacks also showed similar results, in which price reductions on low-fat items increased the proportional purchase of low-fat items by 9%, 39%, and 93% in the 10%, 25%, and 50% price reduction conditions, respectively [51].

Conclusion

Diet rich in antioxidants and micronutrients could reduce the toxic effects of heavy metals in obese children and thus facilitate control of obesity.

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