Nutrición Hospitalaria

Nutr Hosp. 2015;31(5):2054-2061
ISSN 0212-1611 • CODEN NUHOEQ
S.V.R. 318

Original / *Pediatría*

Dietary potential renal acid load in Venezuelan children

Mayerling López-Sayers[1], Jennifer Bernal[2] and Michelle López[3]

[1]Magister in Nutrition, Nutritionist at the "Instituto de Previsión y Asistencia Social para el Personal del Ministerio del Poder Popular para la Educación" (IPASME). Carrizal, Edo Miranda. Venezuela. [2]Doctor in Science, Magister in Nutrition, Nutritionist. Researcher and professor of the Laboratory of Nutritional Assessment. Universidad Simón Bolívar. Caracas. Venezuela. [3]Pediatric Nephrologist. Department of Nephrology. Pediatric Nephrologist at the Children's Hospital JM de los Ríos. Department of Pediatrics. Centro Médico Docente La Trinidad. Caracas.Venezuela.

Abstract

Objective: **Our aim was to determine and analyze the dietary PRAL and food composition pattern in apparently healthy children from 1 to 6 years of age.**

Methods: **Parents of 52 children were selected by convenience, in an outpatient clinic of healthy children. Dietary quality and pattern was assessed by 24 hour recall and food frequency questionnaire. We focused on the intake of macronutrients and food groups, such as meats, dairy, fruits and vegetables. Nutrient intake was compared with national and international recommendations. PRAL was determined according to the method described by Remer and Manz. Descriptive statistics and correlations were applied.**

Results: **Dietary intake of proteins, milk and meat was high, while fruits and vegetables intake was low. PRAL was positive in 92% of the children and correlated ($p<0.05$) with intake of energy, proteins, fat, meat and dairy products. Protein intake was above 2.5 g/kg/day in 46.2% of the children. Food groups with the highest unbalance were meat and dairy products for excessive intake and fruits and vegetables regarding low intake, both of which represent risk factors for endogenous acid production.**

Conclusion: **The diet of the children studied was characterized by an excessive acid load with the risk for the generation of systemic acidosis and its metabolic consequences.**

(*Nutr Hosp*. 2015;31:2054-2061)

DOI:10.3305/nh.2015.31.5.8187

Key words: *Potential Renal Acid Load (PRAL). Protein intake. Fruit intake. Vegetable intake. Children.*

CARGA ÁCIDA POTENCIAL RENAL DE LA DIETA EN NIÑOS VENEZOLANOS

Resumen

Objetivo: **Determinar y analizar la carga ácida potencial renal de la dieta (Potential Renal Acid Load PRAL) y el patrón de alimentación de niños entre 1 a 6 años aparentemente sanos.**

Métodos: **Se seleccionaron según conveniencia a padres de 52 niños asistentes a una consulta de niños sanos. La calidad de la dieta y el patrón de alimentación se evalúo mediante un recordatorio de 24 horas y un cuestionario de frecuencia de alimentos. Se calculó la ingesta de macronutrientes y grupos de alimentos, como carnes, lácteos, frutas y verduras. La ingesta de nutrientes se comparó con las recomendaciones de energía y nutrientes. El PRAL se determinó según el método de Remer y Manz, para determinar la carga ácida de la dieta. Se aplicó estadística descriptiva y correlaciones entre el PRAL, nutrientes y grupos de alimentos.**

Resultados: **La ingesta de proteínas, de leche y de carnes fue elevada, mientras que la ingesta de rutas y hortalizas fue baja. El PRAL fue positivo en 92% de los niños, se asoció con mayor ingesta de energía, proteínas, grasas, carne y lácteos. La ingesta de proteínas fue > 2,5 g/kg/día en 46,2% de los niños. Los grupos de alimentos con mayor desequilibrio debido a exceso fueron la carne y los productos lácteos, mientras que por déficit fue el grupo de frutas y hortalizas.**

Conclusión: **La dieta se caracteriza por una elevada carga de ácido o PRAL, lo que aumenta el riesgo de acidosis sistémica y sus consecuencias metabólicas.**

(*Nutr Hosp*. 2015;31:2054-2061)

DOI:10.3305/nh.2015.31.5.8187

Palabras clave: *Carga ácida potencial renal (PRAL). Ingesta de proteínas. Ingesta de frutas. Ingesta de verduras. Niños.*

Correspondence: Michelle López.
Department of Pediatrics. Centro Médico Docente La Trinidad.
Caracas. Venezuela. Postal code: 1080.
E-mail: michellelopez@cantv.net

Recibido: 6-X-2014.
Aceptado: 10-I-2015.

Introduction

Acid base homeostasis is essential for body metabolism. This delicate balance can be altered by modern diets, especially by those consumed in western societies due to their high content in acid producing elements (sulfur, phosphorus, chloride) provided mostly by foods of animal origin, in comparison with food precursors of bicarbonate anions contained particularly as metabolizable and combustible organic acid anions in fruits and vegetables[1]. A moderate increase in blood levels of hydrogen ions as a result of an acidic composition of the diet may lead to decrease in the extracellular concentration of bicarbonate, which can have long-term implications for the development and progression of various pathological conditions[1-3]. Excess consumption of animal protein, cereals, and grains have been shown to have lowering effects on blood pH, primarily due to the metabolism of sulfur-containing amino acids, such as cysteine and methionine[4]. This increased endogenous acid production can cause a mild form of metabolic acidosis which interferes with the skeleton homeostatic systems that increase bone resorption in order to release alkaline salts (calcium and potassium citrate) in defense of acid base balance. This subclinical low grade metabolic acidosis may lead – in the long-term - to a progressive and gradual decrease in bone mineral content, growth retardation in children, risk for osteoporosis and sarcopenia in adults and elderly people, hypercalciuria, and kidney stone formation[1,5-10].

Fruits and vegetables may be utilized by the body to improve the dietary acid-base balance, without diminishing the consumption of acid forming foods. The protein/potassium ratio has been suggested as an indicator of the acid base balance of the diet. This ratio considers one component of each side of acid base metabolism: protein on the acid side and potassium on the alkaline side[11]. Another method that estimates the acid load of food and diet is the calculation of the Potential Renal Acid Load (PRAL) developed by Manz and Remer, which estimates endogenous acid production in excess of the level of alkali produced by a given amount of food consumed daily[12]. Fish, meats, dairy and grain products have a high PRAL; while fruits and vegetables have a negative PRAL.

Few studies have been published on the dietary acid load in healthy people, especially in children[13-16]. The aim of this study was to determine and analyze the dietary PRAL and food composition pattern in apparently healthy children from 1 to 6 years of age in Caracas, Venezuela.

Methods

This cross-sectional study was held in an outpatient clinic of healthy children between 1 to 6 years of age in Miranda state, Venezuela, between November 2009 and February 2010. Children' parents were invited to schedule a nutritional evaluation appointment. They were informed about the research and were asked to sign an informed consent form, according to the guidelines of Helsinki declaration.

The interview included personal and family history of the child, dietary intake, and whether or not they were taking any medication. Children with acute pathologies that could interfere with normal intake or growth, such as fever or digestive disorders, chronic pathologies such as diabetes mellitus, heart disease, hypothyroidism, chronic renal disease, severe malnutrition or cancer were excluded, as well as children who were receiving medication (antibiotics, antipyretics) that could also interfere with normal intake. Weight and height were measured in all children. A non-probabilistic sample of 133 children met the inclusion criteria, although 61% did not attend the interview. Our final sample was composed by 52 parents of apparently 52 healthy children that responded the food questionnaire and were measured.

Dietary intake. We assessed dietary intake by 24 hour recall (R24H) and food frequency questionnaire (FFQ). Quantitative data (mean and standard deviation of energy, macronutrients and food groups) was obtained with the R24H, while the FFQ allowed us to obtain qualitative information in regard to the usual intake pattern. To increase memory recall with the R24H, we used household measures like cups, glasses, plates and spoons. Three-dimensional wooden forms of different sizes were used to estimate food serving sizes. The FFQ included 102 food items with five options of responses: daily, 3- 4 times a week, every 2 weeks, monthly and never.

The number of servings consumed, the nutrient adequacy and the number of daily meals were obtained from the FFQ. Foods included in the FFQ were grouped in the following food groups: 1.- Breads and other grain based foods, 2.-Meats and eggs, 3.- Milk and other dairy products, 4.- Vegetables, 5.- Fruits, 6.- Fats and 7.- Other foods (sweets, snacks, sugared beverages). Nutrient intake was determined based on energy, protein, fat and carbohydrate compared to the reference values of energy and nutrients for the local population established by the Venezuelan National Institute of Nutrition (NIN)[17]. Nutritional values that did not appear in the Venezuelan Food Composition table[18] were obtained through the nutrition facts data. The cut-off points for considering adequacy of the nutrient intake were: <85% low adequacy, 85% to 115% normal adequacy, and > 115% high adequacy[19]. The dietary data was compared with the Venezuelan[18], American[20] and Chilean[21] food guides for children.

Assessment of dietary PRAL. To determine dietary PRAL we calculated for each child the type and amount of food consumed as reported in the R24H and then derived from PRAL values established for each type of food[12]. The dietary PRAL was calculated by the amount of acid equivalents (positive values) or alkali equivalents (negative values) in each food consumed based on 100 g of cooked or ready to eat foods. Negative values of PRAL indicate an excess of base precursors (represented by fruits and vegetables), and positive values indicate an excess of acid precursors (represented by meats, fish, dairy and grains)[12].

Assessment of nutritional status in children. Measures of weight and height were obtained according to the guidelines of the International Biological Program[22]. By means of these two measurements, the indicator of body mass index-for-age (BMI-for-age) was constructed, and categorized using percentiles. The reference value was based on the growth package recommended by WHO AnthroPlus®. The categories of BMI-for-age were: excess ≥p85, normal >p15 - <p85, and deficit ≤p15[23].

Statistical Analysis. Basic descriptive (represented with mean, standard deviation, maximum and minimum values, frequencies and percentages) and bivariate statistics, such as Pearson correlation were applied. Associations between dietary PRAL and energy, macronutrients and daily food servings were established. Significance level was considered as $p < 0.05$. Analysis was performed using SPSS v 20.

Results

The study sample was constituted by 25 boys (48.1%) and 27 girls (51.9%), with a mean age of 4 years (4.30 ± 1.25). According to the WHO standard for BMI, 75% of children were classified with normal nutritional status, while the rest were above the 85th percentile. None of the children were classified with nutritional deficit. Height for age was adequate in 96 % of the sample (percentiles 15-85) and below the 15th percentile in two boys.

Main demographic and diet characteristics are shown in Table I. We did not find any statistical differences between nutrients and selected food groups across gender. The mean consumption of protein was 44.20 g/day and 2.54 g/kg/day; cereal intake was above 300 g/day; and dairy products were consumed daily by eight out of 10 children, with a mean of 87 gr/. These intakes were above the Venezuelan recommendations. Mothers reported that their children (1- 3 y) consumed high quantities of milk, especially through formula, chocolate milkshakes and beverages with cereals (wheat and rice). In children between 4 to 6 years, yogurt and milk intake was even higher, because they were used in different types of beverages (chocolate milk, coffee, milk shakes), with cereals, in pancakes or alone. Cheese was one of the most frequently consumed foods, as 52% of the children consumed it on a weekly basis.

Red meats and fish were not consumed daily by these children. The highest frequency in weekly intake was for red meats with 90.4%, 88.5% for chicken, and 65.4% for sausage. Fish was consumed once a week by 25% of the children.

The "arepa" (a traditional maize bread) was consumed by all children, followed by cereal based beverages (48%) and bread (31%). The most frequently consumed foods on a weekly basis, were pasta (96.2%), rice (82.7%), legumes (78.8%), crackers (65.4%), and sugared corn cereals (63.4%) (data not showed), all of these with a high PRAL.

Table I
Sample and dietary characteristics in Venezuelan children (n=52)

Characteristics	*Girls (n=27)*				*Boys (n=25)*				*All (n=52)*			
	Mean	*SD*	*Min*	*Max*	*Mean*	*SD*	*Min*	*Max*	*Mean*	*SD*	*Min*	*Max*
Age (years)	3.99	1.10	1.40	6.30	4.64	1.34	1.10	6.60	4.30	1.25	1.10	6.60
Weight (Kgs)	16.94	4.08	10.40	27.50	19.44	3.73	10.40	27.40	18.14	4.07	10.40	27.50
Height (cms)	101.96	9.24	78.00	124.00	108.55	9.89	80.00	125.00	105.13	10.03	78.00	125.00
Calories (Kcal/day)	1267.78	207.61	1040	1450	1342.40	200.85	1080	1490	1303.65	205.85	1040	1490
Proteins (g/day)	41.30	18.36	11.46	86.76	47.32	15.68	26.86	73.05	44.20	17.23	11.46	86.76
Proteins (g/Kg/day)	2.53	1.05	0.70	5.40	2.54	0.84	1.20	4.30	2.54	0.94	0.70	5.40
Fat (g/day)	44.78	24.22	9.64	121.22	52.49	21.63	14.72	109.24	48.48	23.11	9.64	121.22
Carbohydrates (g/day)	184.03	80.40	82.61	502.53	212.63	55.84	104.32	302.14	197.78	70.51	82.61	502.53
Cereals, legumes (g/day)	265.91	122.16	0	273	349.52	130.22	110.00	610.00	306.11	131.78	104.75	610.00
Milk dairy (g/day)	95.79	145.45	0	615	78.13	119.66	0.00	480.00	87.30	132.67	0.00	615.00
Meat (g/day)	94.68	64.30	0	273	118.02	79.88	0.00	315.00	105.90	72.45	0.00	315.00
Fruits (g/day)	96.22	120.88	0	500	135.06	163.97	0.00	695.00	114.89	143.13	0.00	695.00
Vegetables (g/day)	32.85	58.74	0.00	182.5	19.40	34.22	0.00	110.00	26.38	48.54	0.00	182.50

Table II
Diet adequacy for energy and protein

	Nutrient adequacy					
	Girls (n=27)		*Boys (n= 25)*		*All (n=52)*	
	n	*%*	*n*	*%*	*n*	*%*
Low						
Energy	9	33.3	3	12.0	12	23.0
Proteins	10	37.0	5	20.0	15	28.8
Adequate						
Energy	10	37.0	13	52.0	23	44.2
Proteins	6	22.2	7	28.0	13	25.0
High						
Energy	8	29.6	9	36.0	17	32.7
Proteins	11	40.7	13	52.0	24	46.1

Low adequate intake: < 85%, adequate intake: 85 – 115%, high intake: > 115% of adequacy.

Fruit intake was below Venezuelan recommendations in 96.2% of the children, especially in 4-6 year olds. Only 15% of the children consumed fruits on a daily basis. Vegetable intake was below the recommendations in 76.9% of the studied children, especially in the group of 4 to 6 year olds. Vegetables were one of the least daily consumed foods: only 12% of the children reported a daily vegetable intake. Vegetables intake was limited to once a week and mainly as part of stews, casseroles, soups and creams. Very seldom were vegetables consumed as salads, due to their very low acceptance by most of the children.

Diet adequacy for energy and protein, classified as low, adequate and high is specified in Table II. Forty four percent of the children had an energy intake within the recommended range, while protein intake was adequate in 25% and high in 46% of the total population.

Table III shows dietary PRAL in Venezuelan children compared with the German children in the DONALD study[13]. Of the 52 children studied, 96.2 % consumed an acidifying diet. The dietary PRAL was higher in boys with an average of 16.52±15.68 vs. 12.24 ± 7.92 mEq/day in girls ($p<0.05$). Plantain was the main contributor to the alkaline load in the children's diet, being one of the most frequently consumed foods during the week (67.3%), similar to potatoes in the German study. Pasta and red meat were the acid contributing foods with highest weekly intake (96.2% and 90.4% respectively). Dairy products were consumed daily by 83% of the children. These include more alkali rich milk and yogurt and acid equivalent rich cheeses.

Table IV shows the correlation of dietary PRAL with energy and nutrients intake, as well as with food servings. A significant and positive correlation was demonstrated between dietary PRAL and energy, protein (Fig. 1) and fat intake ($p \leq 0.01$). A statistically significant positive correlation ($p \leq 0.01$) was demonstrated between PRAL and consumed meat servings. There was also a statistically significant positive correlation ($p \leq 0.01$) between dietary PRAL and dairy products intake. On the other hand there was a negative, although not significant correlation between dietary PRAL and the consumption of vegetables and fruits.

Discussion

The majority of the children in this study presented a dietary acid-base imbalance with a predominance of acidifying diets, which was associated with the high consumption of acid forming foods, such as meat, chicken, grains and pasta, and the very low consumption of alkali-forming foods such as fruits

Table III
Diet Potential Renal Acid Load (PRAL in mEq/day) in Venezuelan children and for reasons of comparison also in German children. Given values are means ± SD (Min-Max)*

	PRAL (mEq/day)		
	Venezuelan children	*German children (DONALD study)*	
	1-6 years (95% CI Min-Max)	*3-7 years (519 children)*	*8-14 years (220 boys, 225 girls)*
Boys (n=25)	16.52 ± 15.68	-	13.3 ± 12.4
	(-8.88-62.83)		
Girls (n=27)	12.24 ± 7.92	-	9.5 ± 10.3
	(1.20 – 29.72)		
Total	14.29 ± 12.34	5.9 ± 8.6	-
	(-8.88-62.83)		

*Participants of the DONALD study according to Alexy et al.[13].

Table IV
Pearson's correlation between dietary PRAL, nutrients intake and food servings consumed daily in children (n=52).

Nutrients and group foods	*Boys*		*Girls*		*Total*	
	r	*p*	*r*	*p*	*r*	*p*
Energy	**0.59**	**≤0.01**	0.11	0.59	**0.32**	**≤0.01**
Protein	**0.62**	**≤0.01**	**0.47**	**≤0.01**	**0.54**	**≤0.01**
Fat	**0.43**	**0.03**	**0.38**	**0.05**	**0.42**	**≤0.01**
Carbohydrates	0.36	0.07	-0.14	0.49	0.16	0.27
Meats	**0.44**	**0.03**	0.33	0.08	**0.41**	**≤0.01**
Dairy	**0.42**	**0.03**	**0.38**	**0.05**	**0.35**	**≤0.01**
Vegetables	-0.17	0.42	-0.05	0.77	-0.11	0.45
Fruits	-0.19	0.36	-0.33	0.09	-0.22	0.12
Cereals	0.22	0.29	0.17	0.41	0.19	0.18
Oils	0.32	0.12	0.05	0.78	0.25	0.07
Refined sugars	0.16	0.45	-0.18	0.38	0.09	0.53

and vegetables. Dietary PRAL was higher in boys than in girls, similar to what has been observed in a group of children and adolescents 6 to 18 years of age who participated in the German Dortmund Nutritional and Anthropometric Longitudinally Designed (DONALD) study[13], which collects detailed data on diet and growth in healthy subjects from childhood to adulthood. Interestingly, dietary PRAL in the Venezuelan children was markedly, i.e. about 10 mEq/day, higher than in similar age (3-7 years) German children, and even still higher than in the older German DONALD study participants (age: 8-14 years), demonstrating a clearly more acidifying nutrition in these low-middle class children from Venezuela compared to Germany. At a comparable protein intake level, this average 10 mEq/day difference between our and the German children would translate into a difference of about 300 g fruit and vegetable intake/day to compensate for this unequal acid load levels[12].

A significant positive correlation was found between dietary PRAL and daily meat and dairy products servings. There was also a statistically significant po-

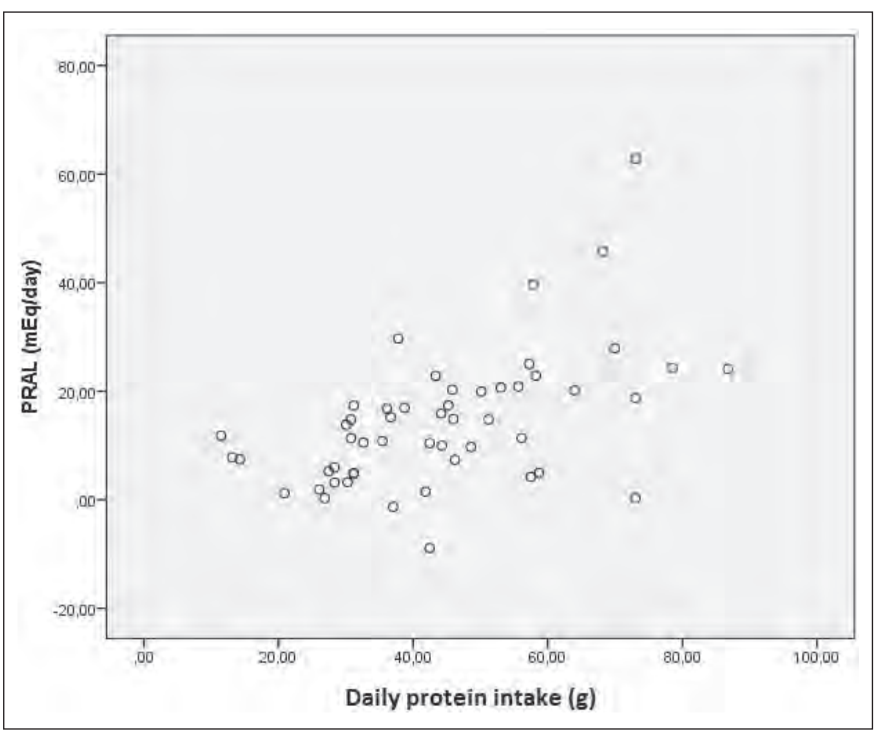

Fig. 1.—Pearson's correlation between dietary PRAL and protein intake (r=0.54; p<0.01).

sitive correlation between dietary PRAL and energy, protein and fat intake. On the other hand, we found a negative, although not significant association between dietary PRAL and the consumption of vegetables and fruits. Our data show similar results as those reported by the German DONALD study, which presented a negative, albeit not significant association between dietary PRAL and the consumption of fruits and vegetables, and a significant positive association with the consumption of dairy, cereals and meats. The daily average of PRAL in that study was positive in all ages and both genders. Another study with similar results was conducted in Chinese adolescents. It showed a significant positive correlation between net endogenous acid excretion and meat intake, whereas this correlation was negative with the consumption of fruits, vegetables and dairy[24].

Protein intake in this study was high when compared with protein requirements recommended for both genders regardless of their age. The average consumption of protein in g/kg/day was within the ranges set forth in the reference values of energy and nutrients for the Venezuelan population in 2000[18]. However a significant number of children had protein intakes much higher than these recommendations. In this regard, it is important to note that the protein requirements suggested by the NIN in 2000 were practically double as high as the international recommendations. Therefore we have to state that both the adequacy of protein intake as well as the number of children who consumed high protein diets in this study would have been twice as high as what we have reported, if we had compared protein intake with international recommendations. The above mentioned study in Chinese adolescents also reveals that protein intake was above recommended requirements[24], which adds to the evidence that protein intake is becoming high even in populations with traditionally low protein intake.

Excessive protein intake by children and adolescents has particular connotations nowadays because modern society follows a paradigm that encourages protein consumption above other nutrients and assigns them an overvalued importance as growth determinants. Local and international studies, both in adults and in children**,** have reported that in most of the industrialized countries and in many developing countries, protein intake exceeds international recommendations[25-30]. Studies published in our country report adequacy percentages for protein intake between 121 and 209% as compared with the requirements recommended for different ages[29,30]. Even in low-income populations, some authors have reported that more than 50% of children consume high protein diets[31]. These diets are usually accompanied by lower fruit and vegetable intakes, which was quite obvious in our children whom consumed these alkalinizing foods in amounts well below national and international recommendations. This pattern was similar to that reported in a previous study conducted in children aged 4 to 14 years in a low income urban community north of Valencia–Venezuela which reported that fruits and vegetables were among the least consumed foods[32]. Intake of fruits and vegetables is an evidence-based strategy that improves dietary acid base balance without reducing the consumption of acid forming foods. Fruits and vegetables are considered as protective factors in the diet because of their high content of potassium and magnesium, which are alkali forming nutrients[33,34].

Metabolic effects of acidifying diets derived from high protein, high sodium chloride and insufficient plant foods intake are quite variable in nature, including subclinical low grade metabolic acidosis and disorders of bone metabolism, renal and endocrine function such as alterations in the efficiency of growth hormone, IGF-1, insulin, steroids, thyroid hormone, parathyroid hormone and vitamin D[35-39]. We could not demonstrate these metabolic effects in this sample due to the cross-sectional nature of our research. Moreover longitudinal studies are necessary to evidence causality of acidifying diets and its deleterious consequences in growth.

The clinical consequences of these unfavorable metabolic responses can, in the long-term, include growth disorders in children, loss of bone and muscle mass in adults, hypercalciuria, hyperuricosuria and urolithiasis in adulthood as well as in childhood. Alterations in bone and muscle metabolism may occur despite only slightly diminished serum bicarbonate levels, within the ranges accepted as normal[35-40]. The association between high PRAL and reduced bone anabolism and bone mass has been confirmed in recent studies[41,42], and with regard to children it may be present in those with urinary calcium in the upper normal values[43]. Although it could be speculated that a high PRAL could be associated with some degree of growth retardation due to low grade metabolic acidosis, preliminary analysis in the present study did not show associations between PRAL and height or weight for age. Probably larger samples or the availability of more particularly characterized control data for specific sample comparisons would be necessary to demonstrate such association.

Several interventional studies have shown that many of the disorders mentioned above may be prevented and reversed by increasing the dietary alkaline content. Nowadays, due to the phenomenon of industrialization and the adoption of unhealthy lifestyles, alkali-rich fruits and vegetables have been replaced by cereal grains and nutrient-poor foods, leading to a dietary acid load that can reach an average of 50-100 mEq/day for western diets. There is a consensus that diet can greatly affect the acid base status of the body and several studies have shown that the acid burden of a person can be manipulated by dietary intervention[13,15,33,34,44-47]. With the exchange of only a few protein rich or alkali poor food products for others with high alkali content, it is possible to markedly reduce the dietary acid load.

We conclude that most of the children in this study had inadequate eating habits characterized mainly by high intake of proteins, fats and carbohydrates, combined with poor consumption of fruits and vegetables, all of which generate a dietary acid-base imbalance with a predominance of a positive PRAL. The consequences of this acidic load could be prevented and treated with a balanced and varied diet with adequate amounts of all food groups. In this sense, education in nutrition plays a key role at very early ages, when the acid-base imbalance that occurs in apparently healthy individuals could be caused by inadequate feeding habits.

Acknowledgements

M.L.S, J.B and M.L designed the research, M.L.S. conducted the research, M.L.S, J.B and M.L analyzed the data, M.L. and J.B. wrote the paper, and M.L.S had primary responsibility for the final content. All authors read and approved the final manuscript.

Conflict of interest.

The authors declare no conflict of interest

References

1. Frassetto LA Morris RC, Sellmeyer DE, Todd K, Sebastian A. Diet, evolution and aging. The pathophysiologic effects of the post-agricultural inversion of the potassium-to-sodium and base-to-chloride ratios in the human diet. *Eur J Nutr* 2001; 40 (5): 200-213.
2. Adeva MM, Souto G. Diet-induced metabolic acidosis. *Clin Nutr* 2011; 30 (4): 416-421.
3. Vormann J, Remer T. Dietary, metabolic, physiologic, and disease-related aspects of acid-base balance: Foreword to the contributions of the second international acid-base symposium. *Nutr* 2008; 138 Suppl: 413-414.
4. Rutherfurd SM, Moughan PJ. Determination of sulfur amino acids in foods as related to bioavailability. *J AOAC Int*. 2008; 91(4):907-913.
5. Reddy ST, Wang CY, Sakhaee K, Brinkley L, Pak CY. Effect of low-carbohydrate high-protein diets on acid-base balance, stone-forming propensity, and calcium metabolism. *American Journal of Kidney Diseases* 2002; 40(2): 265-274.
6. Arnett TR. Extracellular pH regulates bone cell function. *J Nutr* 2008;138(2): 415S-418S.
7. Kalhoff H, Manz F, Diekmann L, Kunz C, Stock GJ, Weisser F. Decreased growth rate of low-birth-weight infants with prolonged maximum renal acid stimulation. *Acta Paediatr* 1993; 82:522–527.
8. Ute A, Remer T, Manz F, Neu CM, Schoenau E. Long-term protein intake and dietary potential renal acid load are associated with bone modeling and remodeling at the proxymal radius in healthy children. *Am J Clin Nutr* 2005; 82:1107-1114.
9. Jurgen V, Hannelore D. The role of nutrition in human acid-base homeostasis. *Eur J Nutr* 2001; 40(5):187-188.
10. Welch AA, MacGregor AJ, Skinner J, Spector TD, Moayyeri A, Cassidy A. A higher alkaline dietary load is associated with greater indexes of skeletal muscle mass in women. *Osteoporos Int* 2013; 24(6):1899-1908.
11. Frassetto LA, Todd KM, Morris RC, Jr., Sebastian A. Estimation of net endogenous noncarbonic acid production in humans from diet potassium and protein contents. *Am J Clin Nutr* 1998;68:576–583.
12. Remer T, Manz F. Potential renal acid load of foods and its influence on urine pH. *J Am Diet Assoc* 1995; 95:791-797.
13. Alexy U, Kersting M, Remer T. Potential renal acid load in the diet of children and adolescents: impact of food groups, age and time trends. *Public Health Nutr* 2008; 11(3): 300-306.
14. Kalhoff H, Manz F. Nutrition, acid-base status and growth in early childhood. *Eur J Nutr* 2001; 40(5): 221-230.
15. Remer T. Influence of nutrition on acid-base balance-metabolic aspects. *Eur J Nutr* 2001; 40 (5): 214-220.
16. Remer T, Dimitriou T, Manz F. Dietary potential renal acid load and renal net acid excretion in healthy, free-living children and adolescents. *Am J Clin Nutr* 2003; 77:1255–1260.
17. Instituto Nacional de Nutrición (eds). Requerimientos de Energía y Nutrientes para la Población Venezolana. Instituto Nacional de Nutrición: Caracas, Venezuela, 2001.
18. Instituto Nacional de Nutrición (eds). Guías de Alimentación para el Preescolar. Instituto Nacional de Nutrición: Caracas, Venezuela, 1999.
19. National Research Council (eds). Subcommittee on the tenth edition of the RDAs. Recommended dietary allowances. 10th Edition. National Academy Press: Washington, USA, 1989.
20. U.S Department of Agriculture (eds). Food and Nutrition Service. Dietary Guidelines for Americans. USDA: Washington, USA, 2010. Available at: [http://www.cnpp.usda.gov/Publications/DietaryGuidelines/2010/PolicyDoc/PolicyDoc.pdfAccessed April 2013].
21. Instituto Nacional de Tecnología de Alimentos, Universidad de Chile (eds). Guia de Alimentación Saludable. INTA: Santiago de Chile, Chile, 2012. Available at www.inta.cl/material_educativo/cd/3GuiAli.pdf. Accessed April 2012. [Accessed April 2013].
22. Weiner JS, Lourie SA. Practical Human Biology. Academy Press: London, UK, 1981.
23. WHO AnthroPlus for personal computers Manual: Software for assessing growth of the world's children and adolescents. January, 2011. Available at: http://www.who.int/growthref/tools/en/. Accessed: March 30, 2013.
24. Chan RSM, Woo J, Chan DCC, Cheung CSK, Lo DHS. Estimated net endogenous acid production and intake of bone health-related nutrients in Hong Kong Chinese adolescents. *Eur J Clin Nutr* 2009; 63(4): 505-512.
25. López M. Las dietas hiperproteicas y sus consecuencias metabólicas. *An Venez Nutr* 2009; 22(2): 95-104.
26. Fulgoni VL. Current protein intake in America: analysis of the National Health and Nutrition Examination Survey, 2003-2004. *Am J Clin Nutr.* 2008; 87(5): 1554S-1557S.
27. Ziegler EE. Consumption of cow's milk as a cause of iron deficiency in infants and toddlers. *Nutr Rev.* 2011; 69 Suppl 1:S37-42. doi: 10.1111/j.1753-4887.2011.00431.x.
28. Guigoz Y. Dietary proteins in humans: basic aspects and consumption in Switzerland. *Int J Vitam Nutr Res* 2011; 81(2-3): 87-100.
29. Portillo Z, Solano L, Fajardo Z. Riesgo de deficiencia de macro y micronutrientes en preescolares de una zona marginal; Valencia, Venezuela. *Invest Clín* 2004; 45: 17-28.
30. Torres-Cárdenas M, Mendez B, Landaeta-Jimenez M, Vazquez-Ramirez M. Consumo de alimentos y estado nutricional según estrato socioeconómico en una población infantil de Caracas. *Arch Venez Puer y Ped* 2011; 74: 2-9.
31. Nolan K, Schell LM, Stark AD, Gómez MI Longitudinal study of energy and nutrient intakes for infants from low-income, urban families. *Public Health Nutr* 2002; 5:405-412.
32. Del Real SI, Fajardo Z, Solano L, Páez MC, Sánchez A. Patrón de consumo de alimentos en niños de una comunidad urbana al norte de Valencia – Venezuela. *A Latin Nutr* 2005; 53(3): 279-286.
33. Deriemaeker P, Aerenhouts D, Hebbelinck M, Clarys P. Nutrient based estimation of acid-base balance in vegetarians and non-vegetarians. *Plant Foods Hum Nutr* 2010;65(1):77-82.

34. Schwalfenberg GK. The alkaline diet: is there evidence that an alkaline pH diet benefits health?. *J Environ Public Health* 2012; 727630.
35. Mitch WE. Metabolic and clinical consequences of metabolic acidosis. *J Nephrol* 2006;19 (9): S70-5.
36. Frasetto LA, Morris RC, Sellmeyer DE, Sebastian A. Adverse Effects of sodium chloride on bone in the aging human population resulting from habitual consumption of typical american diets. *Nutr* 2008; 138: 419-422.
37. Trinchieri A, Maletta A, Lizzano R, Marchesotti F. Potential renal acid load and the risk of renal stone formation in a case-control study. *Eur J Clin Nutr* 2013; 67(10): 1077-1080. doi: 10.1038/ejcn.2013.155.
38. Kerstetter JE. Dietary protein and bone: a new approach to an old question. *Am J Clin Nutr* 2009; 90:1451-1452.
39. Remer T, Krupp D, Shi L. Dietary Protein's and Dietary Acid Load's Influence on Bone Health. *Critical Reviews in Food Science and Nutrition* 2014; 54 (9): 1140-1150. doi: 10.1080/10408398.2011.627519.
40. Caso G, Garlick PJ. Control of muscle protein kinetics by acid-base balance. *Current Opinion in Clinical Nutrition and Metabolic Care*. 2005; 8 (1): 73-76.
41. Remer T, Manz F, Alexy U, Schoenau E, Wudy SA, Shi L Long-term high urinary potential renal acid load and low nitrogen excretion predict reduced diaphyseal bone mass and bone size in children. *J Clin Endocrinol Metab* 2011; 96 (9): 2861-2868.
42. Remer T, Shi L, Alexy U. Potential renal acid load may more strongly affect bone size and mass than volumetric bone mineral density. *Bone* 2011; 48 (2): 414-415.
43. Shi L, Libuda L, Schönau E, Frassetto L, Remer T Long term higher urinary calcium excretion within the normal physiologic range predicts impaired bone status of the proximal radius in healthy children with higher potential renal acid load. *Bone* 2012; 50(5):1026-1031.
44. Wynn E, Krieg MA, Lanham-New SA, Burckhardt P. Postgraduate Symposium: Positive influence of nutritional alkalinity on bone health. *Proc Nutr Soc* 2010; 69 (1):166-173.
45. Dawson-Hughes B, Harris SS, Ceglia L. Alkaline diets favor lean tissue mass in older adults. *Am J Clin Nutr* 2008; 87 (3): 662-665.
46. Trinchieri A, Lizzano R, Marchesotti F, Zanetti G. Effect of potential renal acid load of foods on urinary citrate excretion in calcium renal stone formers. *Urol Res* 2006; 34 (1): 1-7.
47. Kanbara A, Miura Y, Hyogo H, Chayama K, Seyama I I Effect of urine pH changed by dietary intervention on uric acid clearance mechanism of pH-dependent excretion of urinary uric acid. *Nutr J* 2012; 11: 39. . doi: 10.1186/1475-2891-11-39.