Evaluation of food intake and excretion of metabolites in nephrolithiasis

Authors
Évellyn Alves Gordiano[1]
Larissa Marques Tondin[2,3]
Renata Costa de Miranda[1]
Deise Regina Baptista[1]
Mauricio Carvalho[1]

[1] Federal University of Paraná (UFPR).
[2] Pontifical Catholic University of Paraná (PUCPR).
[3] Hospital de Clínicas.

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Correspondence to:
Évellyn Alves Gordiano.
Federal University of Paraná.
Rua Ribeirão Claro, nº 259, casa, Fazendinha. Curitiba, PR, Brasil.
CEP: 81250-380.
E-mail: evellyn.ag@gmail.com

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Abstract

Introduction: Nephrolithiasis is a common condition with high prevalence and recurrence, occuring by a complex and multifactorial process. **Objective:** To analyze the main dietary and metabolic characteristics of patients with nephrolithiasis and compare them with a control group. **Methods:** A cross-sectional study with 31 patients with nephrolithiasis (NE) and 18 healthy. By the dietary intake it were observed sodium, calcium, protein, potassium, vitamin C, oxalate and water intake in both groups. Metabolic assessment were analyzed in urinary excretion of oxalate and citrate. The presence of hypertension and body mass index (BMI) was also evaluated. **Results:** In the NE group, it was found that 45.2% had a high intake of sodium and 100% a high intake of oxalate. It was also observed a low calcium, potassium and vitamin C intake by 93.5%, 100% and 94.9% respectively. Regarding protein, only 12.5% had normal protein intake. Concerning water intake, 12.9% had an ingestion less than 1 liter, 54.8% between 1 and 2 liters and 32.3% higher than 2 liters. Hypertension was observed in 64.5% of patients and adequate excretion of oxalate and citrate in 90.5% of them. There was no statistically difference in food intake, BMI and oxalate excretion between groups. However, the NE group showed higher urinary citrate. **Conclusion:** It was found in both groups a high prevalence of overweight patients, a high intake of oxalate and sodium, in addition to inadequate intakes of calcium, potassium and vitamin C. The NE group showed high protein intake and increased excretion of citrate.

Keywords: citrates; calcium oxalate; nephrolithiasis; eating.

Introduction

Nephrolithiasis - a chronic disease[1] that affects between 5% and 15% of the world's population[2-4] - is considered a public health problem.[3] Renal lithiasis occurs in young adults[5-7] and males in particular.[2,7] Incidence peaks in the third and fourth decades of life,[5-7] although children are frequently affected.[2] Approximately 50% of the untreated patients suffer from recurring kidney stones within a period of five years.[8]

Renal lithiasis ranks third among the diseases of the genitourinary system, after urinary infection and diseases of the prostate. Calcium kidney stones are present in 85% of the cases of renal lithiasis. They form due to increases in the levels of urine oxalate, calcium, and uric acid, or decreases in urinary citrate levels.[8]

Most renal calculi have a mixed composition, consisting of approximately 30% of monominerals.[8] One of the most common minerals is calcium oxalate,[8,9] 40% to 50% of which is excreted in the urine after being consumed as part of one's diet.[10] Oxalate can be found in vegetable species, which inevitably makes it an element in human diet. It is present in seeds, including cereals, spinach and some roots. Beets are particularly rich in oxalate.[11]

Stones form in a complex multi-factorial process. Some of the factors associated with calculi formation are the climate,[7,8] one's occupation,[8,10] nutrition,[8,7] age,[2,8] gender,[2,8,10] genetics,[7,8] and metabolic disorders.[8,10]

Urinary supersaturation - considered to be the initiating event in stone formation[4,12] - may result from three main alterations: high levels of substances known to promote stone formation, low levels of substances known to inhibit crystallization,[4,8] and decreased urine volume.[4] Abnormal crystalluria then occurs, along with crystal nucleation, growth and aggregation, thereby developing the grounds for the establishment of nephrolithiasis.[8]

Studies have indicated the existence of an association between dietary factors,[9,13,14] systemic hypertension,[4,15] body weight,[2,15,16] and metabolite excretion[9,14,17] with the stone formation process, in addition to stressing the need to carry out in-depth investigations on the topic in order to identify and correct the imbalances that cause renal lithiasis.

This study aimed to describe and compare the nutritional, dietary, and metabolic profiles of subjects with and without nephrolithiasis.

Methods

This observational cross-sectional study enrolled healthy controls and patients from the Nephrology Outpatient Clinic at the Hospital de Clinicas of the Federal University of Paraná. The individuals with nephrolithiasis had to meet at least one of the following enrollment criteria: renal colic with confirmed hematuria, radiological evidence of nephrolithiasis, or history of spontaneous expulsion or surgical removal of kidney stones. Patients with recurrent nephrolithiasis had to have had more than two calculi with radiological confirmation and had to have been seen at least twice in the clinic. Additionally, enrolled patients could not have been advised by a nutritionist prior to the start of the study. Participants had to be 18 years or older to join the study and be able to understand and sign the informed consent form. Individuals with calcium metabolism disorders such as primary hyperparathyroidism, medullary sponge kidney, renal tubular acidosis, malignant disease, and decreased renal function (creatinine clearance of less than 70 ml/min) were excluded. The study was approved by the Ethics Committee for Research with Humans of the Hospital de Clinicas, Federal University of Paraná.

The biochemical analyses and ensuing data on metabolism related to the excretion of urinary oxalate and citrate were obtained from 24-hour urine tests. Laboratory tests were deemed satisfactory when the minimum reference value for citrate excretion was 320 mg/24h;[18] for excreted oxalate, the maximum reference value was 45 mg/day.[19] Patients previously diagnosed with or on drugs for systemic hypertension (SH) were considered hypertensive.

The nutritional assessment of enrolled patients included an interview and anthropometric measurements. The interview covered the identification of the subjects and factors related to food and fluid intake.

The assessment of oxalate dietary intake of the groups was based on a semi-quantitative Food Frequency Questionnaire (FFQ).[20] The FFQ looked into the monthly frequency with which individuals ate from a wide range of food groups. Patients were asked to fill in a 24-hour dietary recall[21] in addition to the FFQ to have the intake of other nutrients estimated. Online software Avanutri® was used to analyze the data gathered from the patient 24-hour dietary recalls.

The intake of micronutrients - minus oxalate - was verified for adequacy against the reference values of the Recommended Dietary Allowances (RDA) present in the Dietary Reference Intakes (DRI)[22] for each age range and gender. Values for vitamin C, calcium, potassium, and phosphorous were considered adequate when they were equal to or higher than the values in the RDA. Oxalate intake was estimated from the responses to the FFQ. Each food item mentioned in the FFQ had its oxalate content calculated[23] based on the quantities in household weights and measures and the frequency with which the patients reported to eat these foods. The oxalate contents of the food items were added together to yield the total habitual intake of oxalate. Total oxalate intake was then divided by 30 days to yield the mean daily oxalate intake. Oxalate intakes of less than 55 mg/day[24] were deemed adequate.

Adequate intake of sodium was limited to a maximum of 2000 mg/day, as defined by the World Health Organization.[25] Amounts exceeding this threshold were considered inadequate. A nutritional composition software program was used in the evaluation of sodium intake to consider food-intrinsic sodium levels and the sodium present in the salt added to the food. However, added sodium cannot be assessed based on the consumption patterns of the Brazilian population, since the software already accounts for the added salt - and therefore the sodium - in certain preparations.

Necessary protein intake levels were estimated according to Martin & Cardoso.[26] Individuals with normal protein levels in their diets ate 1 to 1.2 g of protein per kilogram of body weight per day. As for fluid intake, patients were asked about how much water and other fluids they had.

In the anthropometric assessment carried out after the interview, enrolled individuals were weighed and measured for their heights. Subjects were asked to wear as little clothing as possible while they were weighed on a portable scale with 150 kg capacity and 100 g readability. The anthropometer in the scale was used for height measurements. Patients were asked to remove their shoes and accessories on their hair and heads, stand up straight in the center of the equipment with arms alongside their bodies and heads up, looking at a fixed point at eye level. Heights and weights were used to calculate the Body Mass Index (BMI) and categorize the subjects according to the criteria of the World Health Organization.[27]

The statistical analysis of nutritional and urinary biochemical parameters was performed on software package SPSS version 17.0 for Windows® (SPSS, Chicago, IL) to allow for further comparisons.

Numerical variables were compared through Student's *t*-test and the Mann-Whitney U test, the latter being used to treat nonparametric data. The chi-square (χ^2) test, Fisher's exact test and the Mann-Whitney U test were used to compare between categorical variables. When the assumptions for application of the χ^2 test were not present, the Mann-Whitney U test was used to check for differences between groups according to rank sum. Fisher's exact test was used for dichotomous variables. The significance level was set at 0.05.

Results

Thirty-one of the 49 enrolled subjects were in the nephrolithiasis (NL) group and 18 in the control group. In the NL group, 16.67% of the individuals were males, *versus* 25.81% in the control. The two groups were not statistically different in this respect (Fisher's exact test; $p = 0.322$).

The assessment of age, BMI, and dietary categorization included the data from 31 patients in the NL group and 18 in the control group. Citrate and oxalate excretion analysis included the information of 21 patients in the NL group and nine in the control group.

Mean age, mean BMI and oxalate excretion were not statistically different between groups. However, citrate excretion was significantly higher in the NL group ($p = 0.039$), as seen in Table 1.

No statistical difference (chi-square; $p = 0.579$) was seen between groups in terms of hypertension, as 64.5% of the subjects in the NL group and 72.2% of the controls were hypertensive. BMI calculations revealed that 12.9% of the individuals with nephrolithiasis had normal weight, 51.6% were overweight, and 35.5% obese. In the control group, 11.1% had normal weight, 33.3% were overweight, and 55.6% obese. There was no statistical difference between groups ($p = 0.236$).

No statistically significant differences were seen in the intake of sodium, calcium, potassium, vitamin C, oxalate, and protein (Table 2).

When micronutrient intake and oxalate levels were analyzed, only half of the individuals in the NL group were found to have ideal levels of sodium intake. Inadequate levels of calcium intake were observed in 93.50% of the patients in the NL group. The same was true for 100% of the individuals in this group for potassium and 83.90% for vitamin C. Most of the individuals enrolled in the study had oxalate intake above recommended levels (Table 3). In terms of metabolite excretion, a greater number of individuals in the NL group had adequate levels of citrate excretion. Although no significant differences were found between groups for oxalate excretion ($p = 0.367$), most of the individuals in the NL group had adequate levels of oxalate excretion (Table 3).

No statistically significant differences were observed in protein intake between groups (Mann-Whitney, $p = 0.313$). A third (33.3%) of the subjects in the NL group were on hypoproteic diets, 12.5% had normal protein intake levels, and 54.2% were on hyperproteic diets. In the control group, 55.6% of the subjects were on hypoproteic diets, 11.1% had normal protein intake levels, and 33.3% were on hyperproteic diets.

Water intake data revealed that 12.90% of the subjects in the NL group drank less than one liter of water, 54.80% had between one and two liters, and 32.30% had more than two liters of water per day. In the control group, 22.20% had less than a liter

Table 1 Characterization of enrolled subjects - groups

	CONTROL		NL		
	N	Mean (DP)	n	Mean (DP)	*p* value
Age	31	52.23 (10.56)	18	52.78 (14.05)	0.877[a]
BMI	31	29.44 (4.92)	18	31.44 (5.30)	0.189[a]
Oxalate excretion	21	23.19 (12.52)	8	25.56 (15.05)	0.659[a]
Citrate excretion	21	812.45 (566.67)	9	458.00 (387.83)	0.039[b]*

[a] Student's *t*-test; [b] Mann-Whitney U test; * Statistically significant difference ($p < 0.05$).

Table 2 Mean micronutrient and oxalate intake in the NL and control groups

	NL (n = 31)	CONTROL (n = 18)	
	Mean (DP)	Mean (DP)	*p* value
Sodium (mg/day)	1670.35 (871.62)	1914.20 (1356.12)	0.756
Calcium (mg/day)	520.66 (436.76)	427.52 (235.60)	0.709
Potassium (mg/day)	1783.50 (1037.91)	1412.01 (667.62)	0.431
Vitamin C (mg/day)	48.96 (88.59)	37.26 (43.54)	0.967
Oxalate (mg/day)	159 (119.27)	115.15 (46.51)	0.29

Mann-Whitney U test.

of water, 44.40% had between one and two liters, and 33.30% had more than two liters of water per day. No statistically significant differences were seen in the water intake level of the two groups (Chi-square; $p = 0.335$).

Discussion

Nutritional care should focus on reducing the incidence and recurrence of nephrolithiasis.[4] Studies have shown that dietary treatments can effectively reduce the formation of kidney stones.[9,12,28,29] Individuals should also be examined for their metabolic status, in order to allow for the economical and efficient identification and correction of substance imbalances that may impact the stone formation process.[8]

Nephrolithiasis has been associated with systemic hypertension.[2] In our study, no significant differences were seen between patients with lithiasis and healthy controls in this respect. However, 64.5% of the individuals in the NL group were hypertensive. Ferraz *et al.*[3] reported that 19.3% of the patients with nephrolithiasis had SH. Other authors have found that hypertensive patients had higher urinary excretion of calcium and oxalate,[4,15] occasionally accompanied by higher incidences of hypocitraturia.[30] However, Taylor *et al.*[30] failed to find an association between urinary calcium excretion and hypertension. There is indication that history of nephrolithiasis may be associated with increased risk of developing hypertension.[31]

Table 3 Percent adequate intake and excretion of micronutrients and urinary metabolites

	NE	CONTROL	
	Adequate	Adequate	*p* value
Sodium	54.80%	61.10%	0.669[a]
Calcium	6.50%	0%	0.526[b]
Potassium	0%	0%	-
Vitamin C	5.10%	16.70%	1.00[b]
Oxalate	0%	5.60%	0.367[b]
Citrate excretion	90.50%	55.60%	0.049[b]*
Oxalate excretion	90.50%	87.50%	1.00[b]

[a] Chi-square; [b] Fisher's exact test; * Statistically significant difference.

Nephrolithiasis has been associated with obesity.[2] Although no significant BMI differences were seen between groups, 87.1% of the subjects in the NL group were overweight. Several studies have observed an association between a high BMI and formation of kidney stones.[2,15,16] Powell *et al.*[32] reported that obesity alone does not increase the risk of recurrence of kidney stones. Nevertheless, individuals with a high BMI are more prone to having urinary crystallization.[4] Some of the main metabolic disorders seen in obese individuals are hypercalciuria, hyperoxaluria, and hyperuricosuria.[4] Powell *et al.*[32] divided obese and non-obese male patients with nephrolithiasis into groups and noted that obese subjects had higher levels of urinary oxalate excretion. No differences were seen between groups in terms of citrate excretion. The authors concluded that generally, despite the differences, the frequency of recurrent kidney stones in obese and non-obese subjects was similar. The authors also looked at obese and non-obese females with nephrolithiasis and found that obese women had a slightly greater number of episodes of kidney stones than non-obese women suffering from nephrolithiasis. Souza *et al.*[4] reported that half of their patients with nephrolithiasis had a high BMI and low levels of water intake.

In our study, no statistically significant differences were seen between groups in terms of sodium intake levels. However, most of the individuals in the NL group (45.2%) had sodium intake above recommended levels. Yet, sodium intake may have been underestimated, since the salt added by the patients was not considered in this study. For example, the 2008-2009 Household Budget Survey (POF 2008-2009)[33] indicated that the daily sodium intake of Brazilian males and females within the same age groups as the population described in our study ranged from 3637.6 mg to 3186.5 mg, and from 2809.3 mg to 2608.0 mg, respectively.

Some studies have suggested that high levels of sodium intake may increase the risk of hypercalciuria,[7,13,15] and that sodium restriction may benefit individuals with idiopathic hypercalciuria.[13] Sodium has also been thought to reduce citrate excretion.[7] However, another study found no association between sodium intake and increased risk of renal lithiasis.[34] Sodium chloride intake by hypertensive subjects deserves consideration, as it maintains blood pressure at high levels and induces increased excretion of calcium.[15]

No significant differences were observed between groups for calcium intake; however, 93.5% of the subjects in the NL group had less calcium than recommended for their gender and age. The association between calcium intake and formation of kidney stones is probably related to calcium forming a complex with oxalate in the bowel, thereby lower calcium intake causes increased absorption of oxalate[10,14,34,35] and compromises bone mineral density.[10] Given that most kidney stones have calcium in them and that hypercalciuria has been associated with the formation of renal calculi, calcium restriction has been adopted as a recommendation for patients with renal lithiasis.[14] Curhan *et al.*[14] assessed the diets of approximately 45,000 men for a period of 4-5 years, and found that the group with higher calcium intake levels (more than 1050 mg/day) had a significantly lower risk of developing kidney stones *versus* the group having less than 605 mg/day of calcium. Borghi *et al.*[28] reported that decreases in calcium intake reduce urinary calcium excretion and may cause increased urinary oxalate excretion, which by its turn increases the risk of subjects developing nephrolithiasis. While some studies have indicated increased risk of nephrolithiasis in low calcium diets,[9,29] others have failed to describe an association between high calcium intake and formation of kidney stones.[14,34] Other authors have also reported decreased formation of kidney stones in subjects on high calcium diets.[17,34] According to Voss *et al.*,[29] diets with adequate calcium levels (1000-1200 mg/day) play an important role for patients more prone to forming calcium oxalate stones. Taylor *et al.*[17] evaluated a group of men and found that higher calcium intake was associated with reduced risk of renal lithiasis. However, this association was not observed in men aged 60 years or older. Another study found that adequate calcium, low protein, and low salt intake decrease urinary oxalate excretion and may explain the reduction in the risk of recurrent nephrolithiasis *versus* a diet low in calcium alone. The authors commented that this difference could be related to different levels of oxalate excretion pursuant to each diet.[28] Some studies have indicated that when calcium is administered in the form of a supplement there is a 20% increase in the relative risk of kidney stone formation.[36,37] Therefore, a daily intake of 800-1200 mg of calcium from food sources is recommended.[7]

Both groups had low levels of potassium intake. Reduced potassium intake increases calcium urinary excretion and the risk of kidney stone formation.[17] Taylor & Curhan[9] reviewed the Health Professionals Follow-up Study (HPFS) and The Nurses' Health Studies I and II (NHS I and NHS II) and concluded that potassium intake was inversely associated with the risk of forming kidney stones; however, this effect was not seen in young women. Other studies have also found that potassium intake is inversely related to the formation of renal calculi[14,17] and may be an important factor in reducing the recurrence of kidney stones.[17]

No significant differences between groups were seen for vitamin C intake, although 83.9% of the individuals with nephrolithiasis had low levels of vitamin C intake. A study carried out with a group of male individuals with vitamin C intake levels adjusted for age found no association between the formation of kidney stones and vitamin C intake.[17] Another study showed that high doses of vitamin C supplements increased the risk of calcium oxalate stones being formed.[35] Traxer *et al.*[38] indicated that 1000 mg of vitamin C supplements ingested twice a day increased urinary oxalate excretion by 20% to 33%. However, Auer *et al.*[39] reported that intakes of up to 4 g/day of vitamin C did not increase oxalate excretion. The benefit generated by the intake of lemon or orange juice was probably caused by the increase in water intake.

The mean intakes of vitamin C observed in our study were 48.96 mg/day for patients in the NL group and 37.26 mg/day for controls. The vitamin C intake levels seen in this study were lower than the values observed in the POF 2008-2009[33] for the Brazilian population in general and the population living in the South of the country.

According to the POF 2008-2009,[33] the mean intake of vitamin C of individuals within the same age range as the subjects in our study ranged from 155.9 mg/day to 167.2 mg/day for males, and 142.7 mg/day to 167.9 mg/day for females. The population living in the South had mean vitamin C intakes ranging from 102 mg/day to 122.6 mg/day for females, and 115.9 mg/day to 83.2 mg/day for males. However, it is important to note that in the dietary assessment methodology used in the POF (2008-2009)[33] the food intakes on two non-consecutive days were recorded, while our study used 24-hour dietary recalls, which may underestimate food intake.

No significant difference between groups was seen in oxalate intake. Subjects in the NL group had a mean intake of 159 mg/day (± 119.27), and 100% of the enrolled individuals had inadequate levels of oxalate intake. In contrast, 90.5% of the individuals in the NL group had adequate levels of oxalate excretion, indicating a possible overestimation in the assessment of oxalate intake. This fact may be explained by the dietary survey used in the study, as the FFQ is a more subjective method, and by the methodological steps taken in an attempt to estimate daily oxalate intake. Holmes *et al.*[11] showed that urinary oxalate excretion increases as oxalate intake is increased. Other authors consider the restriction of oxalate-rich foods essential for patients with diet-related hyperoxaluria.[8] Patients with nephrolithiasis have been reported to have greater absorption of oxalate.[11,29] Even low-oxalate diets offering as little as 10 mg/day of the substance may result in effective absorption and significant contribution to urinary oxalate excretion.[11] However, Curhan *et al.*[14] did not find an association between the intake of oxalate-rich foods and risk of forming kidney stones. Voss *et al.*[29] suggested that patients should be tested for oxalate absorption, so that individualized treatment was offered to subjects with higher absorption levels.

Protein intake did not yield statistically significant differences between groups. However, 54.2% of the individuals in the NL group had high protein intake levels. Some have argued that increased protein intake may increase the formation of renal calculi, given that animal protein intake increases the urinary excretion of calcium,[7,10,17,40] and oxalate,[7] while it reduces citrate excretion[7,8,10,17] and urine pH.[10] Curhan *et al.*[14] found that animal protein intake increases the excretion of uric acid and calcium, and decreases the excretion of citrate, predisposing individuals to the formation of kidney stones. Another study carried out with an exclusively male population found that the risk associated with animal protein intake varied according to the BMI. Animal protein intake has been associated with increased formation of renal calculi only in men with a BMI < 25 kg/m^2.[17] Reductions in protein intake have been thought to result in reduced endogenous synthesis of oxalate.[41] However, controversy still looms over this topic, as some studies point to increases in the rate of recurrent nephrolithiasis in individuals on dietary animal protein restriction,[42] while others fail to report associations between protein intake and increased risk of kidney stones.[32]

No statistical difference between groups was seen in water intake. However, it is recommended that patients with kidney stones drink at least 2.5 liters/day of water.[36] Interestingly, 67.7% of the patients in the NL group had inadequate intake levels, as they had no more than two liters of water per day. Adequate fluid intake is considered essential for patients with kidney stones, as it decreases urinary saturation and prevents the occurrence of various stages of stone formation.[8] Other studies have also indicated that water intake is inversely related to the risk of forming kidney stones.[8,14,17]

Borghi *et al.*[43] studied patients with idiopathic calcium nephrolithiasis and noted that adequate water intake, even when not accompanied by dietary changes, may have a positive effect against recurrence in many patients. A significant increase in urine volume was observed in the individuals enrolled in a study that followed patients advised to increase water intake levels among other things.[12] Carvalho *et al.*[12] advised a group of individuals to increase water intake, decrease salt and protein (approximately 1 g/kg/day) intake, and have 800 mg/day of calcium; significant increases in urinary citrate (368 ± 238 mg/day *vs.* 502 ± 221 mg/day) were observed subsequently. A normal-calcium, low-salt, low-protein diet decreases urinary excretion of oxalate and calcium. When combined with increased water intake, this diet results in decreased urinary saturation and reduced recurrence of kidney stones.[28]

The patients in the NL group had more adequate citrate excretion levels than the subjects in the control group. Contrary to what has been published by other authors, in the NL group 90.5% of the individuals had adequate citrate excretion levels, *versus* 55.6% of the subjects in the control group. Peres *et al.*[2] described hypocitraturia in 23.5% of the patients with nephrolithiasis. Ferraz *et al.*[3] studied 150 patients with nephrolithiasis and found that 29.5% of them had hypocitraturia. Carvalho *et al.*[12] reported that 44% of the patients with nephrolithiasis had a mean citrate excretion of 178 ± 93.3 mg/day and were considered to have hypocitraturia by the author. Thus, hypocitraturia has been considered as a risk factor for the development of kidney stones.[8,14,17] The results seen in our study may be explained by the directions possibly given to the patients by their physicians when they were diagnosed with nephrolithiasis.

No statistically significant differences were observed between groups in relation to urinary oxalate excretion. However, 9.5% of the individuals in the NL group had inadequate oxalate excretion levels. Urinary oxalate is a major factor in the formation of calcium oxalate kidney stones,[29,44] and even small increases in urinary oxalate excretion may increase the risk of patients forming calcium oxalate stones.[9,14,17] Peres *et al.*[2] described hyperoxaluria in 8.0% of the patients with nephrolithiasis, similarly to what was found in our study.

A limitation of our study was the small number of patients enrolled - a fact that stresses the need for studies with a greater number of individuals.

Additionally, the 24-hour dietary recall was used to quantify the previous day's food intake - a method that should be preferably applied for more than one non-consecutive day, allowing thereby a closer estimation of the actual food intake of each patient.[45] This assessment instrument has been put to good use in epidemiological studies, as there is no variation on the mean food intake of the population from one day to the next.[46] Another fact to consider is the method's simplicity of use and quick application, which have made it widely adopted in the world. Although this method does not interfere with the feeding behavior of the individuals and relies on the subject's memories of a recent past, the 24-hour dietary recall seems to underestimate the intake of certain nutrients, especially when applied for one day only.[47,48] This method also relies considerably on the subject's perception over the size of the food servings.[49]

Conclusion

This study served as a basis to improve the understanding of the metabolic profile and food intake pattern of patients with kidney stones treated at the Hospital de Clinicas of the Federal University of Paraná. Both groups were found to have a high prevalence of overweight individuals, high levels of oxalate and calcium intake, and inadequate levels of calcium, potassium and vitamin C intake. The subjects in the NL group had high levels of protein intake and citrate excretion. Knowledge of the factors associated with the formation of kidney stones may optimize the nutritional care offered to patients with nephrolithiasis.

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Erratum

The paper: "Evaluation of food intake and excretion of metabolites in nephrolithiasis", published in the October 2014 issue of the Brazilian Journal of Nephrology [J Bras Nefrol. 2014; 36: 437-445] there has been a change made to the Table 1 of this paper, and we added another author: Maurício Carvalho.