RESEARCH BRIEF

A Pilot Study on the Relation Between Dietary Calcium and Clinical Parameters in Renal Transplant Recipients

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Objective: This aim of this study was to evaluate the association between dietary calcium and variables that include body mass index, abdominal obesity, metabolic profile, and blood pressure levels in renal transplant patients.
 Design: A cross-sectional study was conducted.
 Setting: Eligible patients were recruited from renal transplant outpatient clinics at Pedro Ernesto University Hospital, Rio de Janeiro, Brazil.
 Patients: A total of 40 men and 34 women aged >18 years who had received kidney transplants in the past ≥12 months were included in this study.
 Intervention: All patients underwent clinical, dietary, anthropometric, and biochemical evaluation.
 Results: Participants were classified into the following 2 groups on the basis of their mean dietary calcium intake: group A (<600 mg/day) and group B (≥600 mg/day). Patients in group B presented significantly lower levels of waist circumference and waist-to-hip ratio as compared with those in group A ($P = .04$ and $P = .005$, respectively), after adjusting for confounding variables such as energy intake, gender, age, physical activity, time since transplantation, and prednisone dose. After controlling for potential confounders, including energy intake and physical activity, subjects in group B had a lower odds ratio for prevalent abdominal obesity as compared with those in group A (odds ratio, 0.17; 95% confidence interval, 0.03 to 0.94; $P = .04$). Body mass index was significantly lower in patients with higher calcium intake; however, this difference did not reach statistical significance after adjustments for confounding factors. Metabolic profile and blood pressure levels were similar in both groups.
 Conclusion: The findings of the present study suggest that a higher dietary calcium intake may be associated with lower abdominal adiposity in renal transplant patients.

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OVER THE PAST several years, advances in surgical techniques, medical care, and mostly in immunosuppression have considerably improved short-term graft and patient survival after kidney transplantation. However, the long-term outcome with a functioning renal graft is limited by chronic graft rejection and early death.[1] Cardiovascular diseases (CVD) are the most common cause of death in renal transplant recipients. The prevalence of several CVD risk factors, such as obesity, hypertension, diabetes, and dyslipidemia, is very high in these patients.[2]

Obesity is a public worldwide health problem and an independent predictor of cardiovascular

morbidity and mortality in the general population,[3] as well as in renal transplant recipients.[4,5] An increase in body weight is very common after transplantation, ranging from 10% to 20% during the first year after surgery.[6] Obesity after transplantation may be a potential risk factor for graft loss, independent of other known risk factors such as hypertension, diabetes, and proteinuria.[7,8] A body mass index (BMI) of >35 kg/m^2 is related to an increase in the risk of CVD, graft loss, and death.[9]

An inverse relationship between dietary calcium and adiposity indexes was found from several epidemiological studies conducted in the general population.[10–15] However, the results of some clinical trials[16–19] designed to examine the effects of calcium supplementation on adiposity had ambiguous results.

Following is one of the suggested mechanisms of action for calcium on adiposity: a low calcium intake raises serum levels of 1,25 dihydroxyvitamin D [1,25(OH)$_2$D] and parathyroid hormone (PTH). These hormones stimulate adipocyte calcium influx, which could promote lipogenesis and inhibit lipolysis. In contrast, a rich calcium diet suppresses 1,25(OH)$_2$D and PTH release.[20]

Recent evidence suggests that, in the general population, rich calcium diets may also help reduce abdominal obesity[19], increase insulin sensitivity[21], improve lipid profile[11], and modulate blood pressure levels.[22]

In chronic kidney disease, PTH secretion is persistently stimulated, leading to secondary hyperparathyroidism.[23,24] During the first months after transplantation, successful renal transplants correct, in part, the metabolic and endocrine disorders that lead to secondary hyperparathyroidism.[25] However, after 1 year of transplantation, PTH levels are twice the normal range in about 50% of the patients, and in 27% after 2 years.[24,25]

The role of dietary calcium intake on adiposity, metabolic profile, and blood pressure in renal transplant patients still remains to be evaluated. Therefore, the purpose of this study was to evaluate the association of dietary calcium consumption with BMI, abdominal obesity, metabolic profile, and blood pressure levels in renal transplant patients.

Methods

This cross-sectional study was conducted with renal transplant outpatients from the Pedro Ernesto University Hospital. Participants included men and women aged >18 years of Brazilian multiethnic origin, who had received kidney transplants in the last ≥ 12 months. The exclusion criteria were as follows: (1) use of any drug for weight loss, (2) current calcium and vitamin D supplementation or use of any drug that could interfere with calcium metabolism, (3) recent changes (last 3 months) in body weight, and intensity or frequency of physical exercise, (4) chronic graft dysfunction (creatinine clearance, <60 mL/minute), (5) acute illness, and (6) mental disorders.

The study protocol was approved by the Ethics Committee of Pedro Ernesto University Hospital. All participants gave written informed consent and were submitted to clinical, dietary, anthropometric, and biochemical evaluation.

The dietary intake of the patients was assessed over three 24-hour recalls covering 2 weekdays and 1 weekend day. The first 24-hour recall was performed face-to-face on the same day as the clinical and anthropometric evaluation, and the other 2 were performed through a telephonic conversation, 1 month after the first interview. The 24-hour recall was conducted by 2 registered dietitians, who were suitably trained to ask respondents to enumerate in detail all information related to the food and drink they had consumed in the past 24 hours, including their quantity. Nutrient analysis of the 24-hour recall was performed using software NutWin (São Paulo Federal University, UNIFESP, São Paulo, Brazil). An average of 3 days was used in the analysis.

Anthropometric parameters that were evaluated included: body weight, height, triceps skinfold, and the circumferences of mid-arm, waist, and hip. All the anthropometric measurements were taken thrice by the same person and the average of the measurements was used in the analysis. Height was measured using a stadiometer and weight was obtained with a Fillizola calibrated scale, accurate to ± 0.1 kg, with subjects wearing light clothing and no footwear. BMI was calculated using the standard equation (kilograms per meters squared) and was classified according to World Health Organization criteria.[26] Participants were considered to be obese when their BMI values were ≥ 30 kg/m^2.[26]

The triceps skinfold and mid-arm circumferences were measured at the mid point between the acromion and olecranon. The skinfold was measured with a lange skinfold caliper (Beta Technology, Santa Cruz, CA, USA) to the nearest

1 mm. Mid-arm muscle circumference was obtained by using the following formula: (mid-arm circumference [cm]) $-$ ($\pi \times$ triceps skinfold [cm]).

Waist circumference was measured in the standing position, midway between the lower margin of the last rib and the iliac crest. The measurements were taken at mid-exhalation. Hip circumference was measured at the widest point of the area around the hip–buttocks region, with the measuring tape kept parallel to the floor. The waist–hip ratio was determined by dividing waist circumference by hip circumference. Abdominal obesity was defined as having a waist circumference of >102 cm in men and >88 cm in women.[27]

Biochemical evaluation included measuring serum creatinine, serum urea, total cholesterol, high density lipoprotein cholesterol (HDL-cholesterol), triglycerides, glucose, uric acid, calcium, phosphorus, and albumin. Low density lipoprotein cholesterol (LDL-cholesterol) was estimated by using the Friedewald formula.[28] We considered glucose, total cholesterol, HDL-cholesterol, LDL-cholesterol, and triglycerides as components of the metabolic profile. Blood samples were collected after a 12-hour fasting period and all biochemical analysis were performed at the hospital clinical laboratory.

The glomerular filtration rate was evaluated using the creatinine clearance (mL/minute), estimated by using the Cockcroft–Gault equation[29]: $(140 - [\text{age \{years\}} \times \text{weight \{kg\}}]/72 \times \text{serum creatinine [mg/dL]}) \times 0.85$ (for women). We considered time since transplantation as the period from kidney transplantation to inclusion in the present study.

Patients were considered to be hypertensive when their systolic and/or diastolic blood pressure levels were ≥140 and ≥90 mm Hg, respectively, or when they were on antihypertensive therapy.[30] Diabetes mellitus was diagnosed when fasting glucose levels were ≥126 mg/dL or when patients were using insulin or an oral antidiabetic for a minimum of 8 weeks.[31] The diagnosis of dyslipidemia followed the Adult Treatment Panel III (ATP III) criteria,[27] that is, total cholesterol, ≥200 mg/dL; LDL-cholesterol, ≥130 mg/dL; and triglycerides, ≥150 mg/dL; or use of lipid-reducing drugs.

Participants were also stratified on the basis of their lifestyle behavior (alcohol intake, smoking habits, and physical activity). Patients who drank alcohol beverages for a minimum of once a week were considered as being alcoholics. Subjects who smoked a minimum of 1 cigarette a day were considered smokers. Individuals who practiced activities, including light exercise, for a minimum of 3 times a week for about 40 minutes each were considered as having physical activity.

Statistical Methods

Means and standard errors were used to summarize continuous variables. To test the possible association of dietary calcium intake with anthropometric parameters, biochemical variables, and blood pressure levels, participants were stratified into 2 groups on the basis of their mean habitual dietary calcium intake. Because the mean dietary calcium intake in this study was 554.20 ± 39.96 mg/day, a cut-off point of 600 mg/day was selected to establish the 2 groups. Patients with an intake of <600 mg/day were allocated into group A and those with an intake of ≥600 mg/day were allocated into group B. Continuous variables were compared between the 2 groups using the Student's t test, and multiple linear regression analysis was used to adjust for confounding factors. Comparisons among proportions were performed by using the χ^2 test. Multiple logistic regression analysis was used to evaluate associations between calcium intake and the presence of obesity, abdominal obesity, diabetes, dyslipidemia, and hypertension. STATA 8.2 (STATA Corp., College Station, TX) was used for statistical analysis. A P value of <.05 was considered as significant.

Results

A total of 74 renal transplant subjects (40 men and 34 women), with a mean age of 47.4 ± 1.1 years, transplantation duration of 119.78 ± 7.68 months, and mean creatinine clearance of 75.98 ± 2.23 mL/minute participated in the present study. After stratifying the participants on the basis of their daily calcium intake (based on the 24-hour recalls) (group A, <600 mg/day, n = 49; group B, ≥600 mg/day, n = 25), both groups were comparable in several demographic, clinical, and lifestyle characteristics (Table 1). On the basis of the 24-hour recalls, it was found that calcium intake was significantly lower in group A as compared with group B, whereas energy intake was similar in both groups (Table 1).

BMI was significantly higher in group A than in group B. However, this difference did not reach statistical significance after adjusting for variables that could interfere with BMI (e.g., energy intake,

Table 1. Participants Characteristics According to Dietary Calcium Intake Based on 24-Hour Recalls

	Calcium Intake (mg/day)		
Characteristic	Group A, <600 (n = 49)	Group B, ≥600 (n = 25)	*P*
Age (years)	47.55 ± 1.41	47.24 ± 1.92	.89
Gender (women/men)	26 (53%)/23 (47%)	8 (32%)/17 (68%)	.07
Serum urea nitrogen (mg/dL)	39.80 ± 2.21	46.00 ± 4.16	.09
Creatinine clearance* (mL/minute)	79.15 ± 2.70	70.46 ± 3.68	.06
Total serum calcium (mg/dL)	9.58 ± 0.13	9.60 ± 0.13	.91
Ionized serum calcium (mg/dL)	4.19 ± 0.06	4.20 ± 0.06	.93
Serum phosphorus (mg/dL)	3.48 ± 0.12	3.32 ± 0.15	.45
Serum potassium (mEq/L)	4.17 ± 0.05	4.23 ± 0.10	.56
Total serum protein (g/dL)	7.17 ± 0.07	7.10 ± 0.08	.59
Serum albumin (g/dL)	4.31 ± 0.05	4.32 ± 0.11	.96
Ethnic group (nonwhite/white)	25 (51%)/24 (49%)	11 (44%)/14 (56%)	.57
Alcohol intake (n; %)	11 (22%)	9 (36%)	.17
Smoking habits (n; %)	5 (10%)	4 (16%)	.44
Physical activity (n; %)	11 (22%)	9 (36%)	.23
Calcium intake (mg/day)	359.96 ± 19.37	934.90 ± 61.51	<.0001
Energy intake (kcal/day)	1689.56 ± 69.74	1853.67 ± 77.89	.07
Time from transplantation (months)	122.83 ± 10.16	113.80 ± 11.13	.58
Type of graft donor (living/cadaveric)	36 (73%)/13 (27%)	19 (76%)/6 (24%)	.81
Use of prednisone (n; %)	49 (100%)	25 (100%)	1.00
Dose of prednisone (mg/day)	6.95 ± 0.32	5.98 ± 0.31	.06

Values are expressed as mean ± standard error or percentage.

Time from transplantation = period from transplantation to inclusion in the present study.

P-value refers to differences between group A and group B and was estimated for continuous variables using Student's *t* test and for proportions using the χ^2 test.

*Estimated by using the Cockcroft–Gault equation.

physical activity, gender, age, time from transplantation, and dose of prednisone) (Table 2).

When compared with subjects in group B, group A participants exhibited higher levels of waist circumference, hip circumference, waist-to-hip ratio, triceps skinfold, mid-arm circumference, and mid-arm muscle circumference; however, these differences were not statistically significant (Table 2). However, after adjusting for confounding factors, waist circumference and waist-to-hip ratio values were significantly higher in group A when compared with group B (Table 2).

Comparative analysis of metabolic variables between the 2 groups showed lower serum levels of

Table 2. Anthropometric Parameters Based on Dietary Calcium Intake

	Calcium Intake (mg/day)			
	Group A, <600 (n = 49)	Group B, ≥600 (n = 25)	*P*	*P**
Body weight (kg)	71.51 ± 2.36	68.95 ± 2.31	.48	.28
Height (m)	1.61 ± 0.01	1.66 ± 0.02	.02	.60
Body mass index (kg/m²)	27.56 ± 0.86	24.94 ± 0.58	.04	.11
Waist circumference (cm)	95.85 ± 2.28	90.51 ± 1.91	.13	.04
Hip circumference (cm)	102.00 ± 1.89	98.62 ± 1.27	.22	.79
Waist-to-hip ratio	0.94 ± 0.01	0.91 ± 0.01	.24	.005
Triceps skinfold (mm)	21.41 ± 1.55	16.88 ± 1.44	.06	.74
Mid-arm circumference (cm)	30.45 ± 0.69	28.47 ± 0.69	.07	.09
Mid-arm muscle circumference (cm)	23.72 ± 0.49	23.17 ± 0.70	.51	.06

Values are expressed as mean ± standard error.

P-value refers to differences between group A and group B and was estimated using Student's *t* test. Multiple linear regression analysis was used to adjust for confounding factors.

*After adjustment for energy intake, physical activity, gender, age, time from transplantation and dose of prednisone.

glucose, LDL-cholesterol, and triglycerides in subjects with higher dietary calcium intake; however, these differences did not reach statistical significance (Table 3). Total cholesterol concentrations were similar in both groups. Levels of HDL-cholesterol were higher in group B as compared with A; however, it did not reach significance (Table 3). Even after adjusting for factors that could interfere with metabolic variables (energy intake, physical activity, age, time from transplantation, dose of prednisone, BMI, waist circumference, diagnosis of diabetes, diagnosis of hypertension, antidiabetic drugs or hypolipemic medications), differences between the 2 groups did not reach statistical significance.

Similar levels of blood pressure were also found in both groups (Table 3), even after adjustments for confounding factors (BMI, waist circumference, age, diagnosis of hypertension, and antihypertensive therapy).

After controlling for potential confounders, including energy intake and physical activity, subjects in group B had a lower odds ratio for prevalent abdominal obesity as compared with those in group A. Patients in group B in comparison with group A also presented a lower odds ratio for the presence of global obesity; however, after controlling for confounding variables the difference between the groups disappeared (Table 4).

Discussion

In the present study, using a sample of renal transplant subjects stratified in 2 groups on the basis of their dietary calcium intake (group A, <600 mg/day; group B, ≥600 mg/day), the main findings obtained were as follows: (1) Subjects with lower dietary calcium intake presented significantly greater abdominal adiposity, independently of energy intake, gender, age, physical activity, time from transplantation, and prednisone dose. (2) BMI was significantly higher in patients with lower calcium intake; however, after adjusting for confounding factors, this difference did not reach significance.

Dietary calcium intake observed in this study (mean intake of 554 mg/day on the basis of 24-hour recalls) was lower than the recommended amount for renal transplant patients[32] and for adults in the general population (1,000 to 1,200 mg/day).[33] The low calcium intake found in these patients could be partially explained by eating habits acquired in the pre–dialysis phase of chronic kidney disease, in which patients are instructed to consume a modified protein diet,[34] including dairy products (the major source of dietary calcium). A study conducted in Ireland with renal transplant subjects also observed a mean calcium intake lower than the recommendations (820 mg/day).[35]

As it was previously mentioned, to our knowledge, there has been no published study evaluating the relationship between dietary calcium intake and nutritional profile, metabolic variables, and blood pressure levels in renal transplant patients. Therefore, we are only able to compare our results with those obtained in studies with the general population.

In this study, the subjects with lower calcium intake (group A) did not show significantly higher global adiposity (evaluated by BMI) than the participants with higher calcium intake (group B) after adjusting for confounding variables. Major epidemiological studies, in the general population, which evaluated the relationship between dietary calcium intake and adiposity found negative association between these 2 parameters (as mentioned previously).[10–15]

Table 3. Metabolic Variables and Blood Pressure Levels Based on Dietary Calcium Intake

	Calcium Intake (mg/day)		
	Group A, <600 (n = 49)	Group B, ≥600 (n = 25)	*P*
Glucose (mg/dL)	99.88 ± 4.70	92.54 ± 1.82	.25
Total cholesterol (mg/dL)	203.64 ± 6.31	204.34 ± 7.90	.94
HDL cholesterol (mg/dL)	40.25 ± 2.21	55.00 ± 8.0	.06
LDL cholesterol (mg/dL)	135.1 ± 24.52	119.70 ± 31.10	.73
Triglycerides (mg/dL)	176.17 ± 13.36	167.52 ± 18.05	.70
Systolic blood pressure (mm Hg)	117.76 ± 2.00	121.66 ± 3.44	.29
Diastolic blood pressure (mm Hg)	76.19 ± 1.44	76.25 ± 2.21	.98

Values expressed as mean ± standard error.
P-value refers to differences between group A and group B and was estimated using Student's *t* test.

Table 4. Odds Ratio (95% CIs) for the Prevalence of Obesity, Abdominal Obesity, Diabetes, Dyslipidemia, and Hypertension Based on Calcium Intake

	Calcium Intake (mg/day)		
	Group A, <600 (n = 49)	Group B, ≥600 (n = 25)	*P*
Obesity			
Number of cases (%)	15 (31%)	1 (4%)	–
Odds ratio (95% CI)	1.00	0.09 (0.01-0.76)	.03
Multivariate-adjusted*	1.00	0.11 (0.009-1.36)	.09
Abdominal obesity			
Number of cases (%)	24 (49%)	5 (20%)	–
Odds ratio (95% CI)	1.00	0.27 (0.09-0.85)	.02
Multivariate-adjusted*	1.00	0.17 (0.03-0.94)	.04
Diabetes mellitus			
Number of cases (%)	7 (14%)	1(4%)	–
Odds ratio (95% CI)	1.00	0.22 (0.03-1.88)	.17
Multivariate-adjusted*	1.00	0.12 (0.004-3.16)	.20
Dyslipidemia			
Number of cases (%)	33 (67%)	15 (60%)	–
Odds ratio (95% CI)	1.00	0.56 (0.19-1.62)	.28
Multivariate-adjusted*	1.00	0.59 (0.12-2.84)	.51
Hypertension			
Number of cases (%)	29 (59%)	19 (76%)	–
Odds ratio (95% CI)	1.00	2.07 (0.70-6.14)	.19
Multivariate-adjusted*	1.00	2.36 (0.57-9.89)	.24

Participants were considered to be obese when their BMI values were ≥30 kg/m^2.[26] Abdominal obesity was defined as having a waist circumference of >102 cm in men and >88 cm in women.[27] Diabetes mellitus was diagnosed when fasting glucose levels were ≥126 mg/dL or when patients were using insulin or an oral antidiabetic medication for a minimum of 8 weeks.[31] The diagnosis of dyslipidemia followed the ATP III criteria,[27] that is, total cholesterol, ≥200 mg/dL; LDL-cholesterol, ≥130 mg/dL; and triglycerides, ≥150 mg/dL; or use of lipid-reducing drugs. Patients were considered to be hypertensive when their systolic and/or diastolic blood pressure levels were ≥140 and ≥90 mm Hg, respectively, or when they were on antihypertensive therapy.[30]

Multiple logistic regression analysis was used to evaluate associations between calcium intake and the presence of obesity, abdominal obesity, diabetes, dyslipidemia, and hypertension.

*Adjusted for energy intake, physical activity, gender, age, time from transplantation, and dose of prednisone.

After adjusting for confounding factors, participants with lower calcium intake showed significantly higher values of waist circumference and waist-to-hip ratio and a greater prevalence of abdominal obesity. Similar findings have been found in observational studies.[11,13,14] Some randomized clinical trials with calcium supplementation indicate a significantly higher reduction in abdominal obesity when associated with energy restriction or even with a normocaloric diet, suggesting body fat redistribution.[18,19,36–38]

In the general population, overwhelming evidence supports the importance of obesity in the pathogenesis and progression of CVD.[39] There is accumulating evidence to suggest that the deposition of fat in the abdominal region is associated strongly with the pathogenesis of CVD and related mortality.[40–42]

The proposed mechanism by which dietary calcium intake could induce abdominal obesity reduction is still not clear, although recent studies describing the adipose tissue autocrine cortisol production role would give some plausible explanation.[20] Human adipose tissue expresses the 11β–hydroxysteroid dehydrogenase-1, which catalyses the conversion of cortisone to cortisol. Recently, it was demonstrated that 1,25(OH)$_2$D stimulates the expression of 11β–hydroxysteroid dehydrogenase-1 and cortisol production by human adipocytes.[43,44] Because rich calcium diets suppress 1,25(OH)$_2$D levels, it has been suggested that the reduction on central obesity with these diets could be partly explained by suppression of 1,25(OH)$_2$D levels, leading to a reduction of adipocyte cortisol production.[44]

There are several limitations to our study. One of them is that the number of patients is much lower than the number usually present in the observational studies with which we compared our results. This particular fact may partly explain the

absence of significant association between calcium intake and BMI, metabolic variables, and blood pressure levels. Another possible explanation could be the immunosuppressive regimen, which is known to interfere strongly with the evaluated variables,[45] playing an important role that could overcome the effects of calcium. Another finding that could have interfered with our results is the very low calcium intake in our patients, as only 8 patients had a calcium intake >1,000 mg/day.

In conclusion, the findings of the present study suggest that in renal transplant patients, a higher dietary calcium intake could be associated with lower abdominal adiposity.

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