Original Article

Association of dietary inflammatory index and Chinese healthy eating index with abdominal obesity in kidney transplant recipients

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Background and Objectives: This study investigated associations of the Dietary Inflammatory Index (DII) and Chinese Healthy Diet Index (CHEI) with abdominal obesity in kidney transplant recipients (KTRs), with follow-up analyses further assessing the DII and mortality relationship. **Methods and Study Design:** We collected anthropometric and biochemical data; dietary consumption was evaluated using 3-day and 24-hour dietary records, with food quality assessed through energy-adjusted DII(E-DII) and CHEI. Binary logistic regression examined the association between E-DII, CHEI, and abdominal obesity in KTRs. The nonlinear connection between E-DII, CHEI, and abdominal obesity was studied using restricted cubic spline (RCS) analysis. The Kaplan-Meier survival curve was used to examine the survival rate of KTRs. **Results:** The study included 98 KTRs, 34 of whom had abdominal obesity. Logistic regression identified E-DII was a risk factor for abdominal obesity (OR: 5.52, 95%CI:1.19-10.4, p = 0.023), while the CHEI showed protective effects (OR: 0.939, 95%CI:0.893-0.987, p = 0.014). RCS demonstrated a positive linear association between E-DII and abdominal obesity in KTRs (p for overall = 0.042, p for nonlinear = 0.794). In contrast, CHEI exhibited a negative correlation (p for overall = 0.039, p for nonlinear = 0.082). Kaplan-Meier survival curve analysis revealed no statistically significant difference between groups, but the pro-inflammatory group exhibited a 3.8-fold higher mortality rate than the anti-inflammatory group. **Conclusions:** In KTRs, elevated E-DII and CHEI levels were associated with abdominal obesity, suggesting that reducing E-DII while increasing CHEI may contribute to its prevention and thus improve long-term survival outcomes.

Key Words: dietary inflammation index, Chinese healthy eating index, abdominal obesity, kidney transplant recipient, mortality

INTRODUCTION

Kidney transplantation is a well-established and effective treatment for end-stage kidney disease. Compared to patients undergoing hemodialysis, kidney transplant recipients (KTRs) exhibit a lower mortality rate and an enhanced capacity for self-care,[1] which raises overall satisfaction among KTRs.[2] Graft survival rates following renal transplantation have improved, primarily due to the development of novel immunosuppressants.[3] Studies have shown that KTRs typically experience weight gain ranging from 6 to 14 kg during the first year post-transplantation.[4]

However, obesity in KTRs is associated with a decline

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in quality of life, an unfavorable cardiovascular risk profile, and reduced graft and overall survival rates.[5] Post-transplantation weight gain is primarily attributed to increased body fat, particularly visceral adipose tissue accumulation in the abdominal region.[2] Kovesdy et al. demonstrated that, after adjusting for body mass index (BMI), increased waist circumference is associated with higher mortality, likely mediated by the adverse metabolic effects of visceral adipose tissue.[6] Therefore, addressing post-transplantation weight management and improving long-term survival outcomes in KTRs represent critical clinical and ethical priorities.[7]

Nutrient substances play a critical role in regulating various physiological functions, with diet as the primary source of nutrients.[8] Numerous dietary patterns have been demonstrated to influence the risk of obesity significantly. The Mediterranean diet has been widely recognized as one of the healthiest dietary patterns for mitigating obesity,[9] owing to its association with reduced systemic inflammatory markers, such as C-reactive protein (CRP).[10] In recent years, the Dietary Inflammatory Index (DII), developed by Shivappa et al. in 2009 and further refined in 2013, has emerged as a validated tool for assessing the inflammatory potential of an individual's diet. The DII evaluates 45 food parameters to predict the relationship between pro-inflammatory diets and disease risk. It serves as a reliable indicator for quantifying the impact of dietary factors on systemic inflammation.[11] Pro-inflammatory diets are defined by high consumption of saturated fats and refined carbohydrates, coupled with insufficient intake of polyunsaturated fatty acids, flavonoids, and other antioxidant-rich dietary components.[12] DII has been associated with several inflammatory disorders, including diabetes, cancer, cardiovascular disease, telomere length, chronic renal disease, and more.[13] Winkelmayer et al. have established that the association between inflammation and mortality in kidney transplant recipients follows a J-curve relationship.[14] However, the association between DII and abdominal obesity in KTRs is poorly understood.

The aim of this study is to examine the association between the DII and abdominal obesity in KTRs, and to conduct follow-up analyses of the relationship between DII and mortality in this population, and to evaluate the dietary quality of KTRs using the CHEI, which was developed based on the Chinese Dietary Guidelines (DGC-2016) and the Healthy Eating Index. The CHEI is a validated tool for evaluating dietary quality in the Chinese population.[15] The findings of this study aim to provide evidence-based dietary recommendations for KTRs to improve post-transplantation survival outcomes.

METHODS

Study design and participants

Dietary data were collected from KTRs at the Organ Transplantation Department of the Guangdong Second Provincial General Hospital between September 2021 and December 2022. Inclusion criteria: (1) ages 18 to 80; (2) first kidney transplant; (3) recipient's kidney is normal; (4) able to sign informed consent documents on their own and possess basic writing and language skills; (5) >3 months post-renal transplantation. Exclusion criteria: (1) non-primary kidney transplantation or kidney transplantation in conjunction with other organ transplants; (2) KTRs with other severe physical or mental conditions; (3) poor compliance and an inability to collaborate with researchers; (4) presence of metal stents or pacemakers previously implanted in the body.

The deadline for follow-up investigation is December 2024. During the follow-up period, the time of patients' deaths was recorded. For patients still alive at the end of the observation period, the endpoint was defined as at least 24 months of observation time, and data lost to follow-up were excluded.

The study was conducted in accordance with the Declaration of Helsinki and the Declaration of Istanbul, and it was approved by the Ethics Committee of Guangzhou Red Cross Hospital (Approval No. Sui Hong Hospital 2022-065-01).

Questionnaire survey

Trained investigators conducted a questionnaire survey among the study participants, collecting demographic and clinical data, including sex, type of kidney transplantation, and survival status.

Anthropometric measurements

Anthropometric parameters, including height, weight, blood pressure, grip and pinch strength, calf circumference, upper arm circumference, triceps skinfold thickness, waist circumference, and hip circumference, were measured by trained technicians using calibrated instruments following standardized protocols. Measurements were recorded to the nearest 0.1 cm or 0.1 mm. BMI = weight (kg)/height^2 (m^2); arm muscle circumference (AMC) = upper arm circumference - 0.314 × triceps skinfold thickness.

Biochemical measurement

Participants underwent venous blood collection after a 10-12 hour fasting period. Biochemical parameters, including serum albumin (ALB), alanine aminotransferase (ALT), aspartate aminotransferase (AST), blood urea nitrogen (BUN), uric acid (UA), fasting blood glucose, thyroid hormones, parathyroid hormone, insulin, and other relevant markers, were measured.

Definition of abdominal obesity

According to the Chinese guidelines for prevention and treatment of Hypertension (revised edition 2024), abdominal obesity was defined as a waist circumference ≥ 90 cm for males and ≥ 85 cm for females.

Dietary data collection

In this study, dietary data of KTRs were collected using a 3-day, 24-hour dietary recall method. Subjects' food intake was recorded over three days, alongside their household food purchases. Trained investigators recorded all consumed items, utilizing standard food models to enhance recall accuracy. Self-reported dietary intake was cross-verified against household consumption data to ensure accuracy. Food types were documented, and nutrient content was calculated using the 2018 Chinese Food Composition Table (Standard Edition). Since KTRs represent a distinct population and no alcohol consumption was reported during the study period, alcoholic beverages were excluded from the analysis. Furthermore, due to insufficient data on sugar, it was excluded from the analysis.

Dietary inflammatory index

The DII was developed by Shivappa et al. to evaluate the inflammatory potential of an individual's diet based on 45 food parameters and their effects on six inflammatory biomarkers: interleukin-1β, interleukin-4, interleukin-6, interleukin-10, tumor necrosis factor-alpha, and CRP.[11] The calculation method was detailed in Shivappa et al.'s publication.[12] 22 dietary components were included: energy, protein, fat, carbohydrates, dietary fiber, cholesterol, vitamin A, vitamin B-1, riboflavin, niacin, folic acid, vitamin C, vitamin E, carotene, vitamin B-6, magnesium, iron, zinc, selenium, saturated fat, monounsaturated fatty acid, and polyunsaturated fatty acid. In this study, we used the energy-adjusted data to calculate energy-adjusted DII (E-DII). Participants were grouped according to the E-DII score, with those scoring below zero classified as the anti-inflammatory group (E-DII < 0) and those scoring above zero as the pro-inflammatory group (E-DII > 0).

Chinese healthy eating index (CHEI)

The CHEI is a continuous scoring system developed to assess dietary patterns and changes comprehensively. It comprises 17 food components, including 12 sufficiency components (grains, whole grains, potatoes, vegetables, dark vegetables, fruits, dairy, legumes, seafood, poultry, eggs, and nuts) and five restricted components (red meat, edible oil, sodium, added sugar, and alcohol). The calculation method is detailed in Yuan YQ et al.'s publication.[15] Higher consumption of sufficiency components and a lower intake of restricted components result in higher scores. Each component is scored individually, and the total CHEI score, ranging from 0 to 100, is derived from the sum of all 17 components. Higher scores indicate better dietary quality.

Statistical analysis

Statistical analysis was performed using SPSS 26.0, RCS analysis was conducted using R Studio, and plotting was done using GraphPad Prism 9.5 and R Studio. The basic information of the subjects was described by composition ratio (%). Measurement data satisfying normal distribution was expressed by mean ± standard deviation (mean±SD), and a t-test was used to compare groups. Measurement data that did not meet the normal distribution were represented as medians and inter quartile range (IQR), the Wilcoxon rank sum test was used to compare groups. Logistic regression was employed to analyze the association between E-DII and CHEI of KTRs and the risk of abdominal obesity. A Cox proportional hazards regression model was used to analyze the risk factors for all-cause mortality among KTRs. The Kaplan-Meier survival curve was used to analyze the survival rate of KTRs, and restricted cubic spline (RCS) analysis was used to evaluate the non-linear association between E-DII and CHEI scores and the risk of abdominal obesity. Statistical significance was set at $p < 0.05$.

RESULTS

Baseline characteristics stratified by waist circumference group

Among the 98 KTRs, 64 (65.3%) were classified into the non-abdominal obesity group, and 34 (34.7%) were classified into the abdominal obesity group. Differences in E-DII, CHEI, sex, diastolic pressure, upper arm circumference, AMC, triceps skinfold thickness, waist circumference, red blood cells (RBC), weight, BMI, CO_2 combining power (CO_2-CP), hip circumference, left and right calf circumference, blood glucose, and insulin were statistically significant between the non-abdominal obesity and abdominal obesity groups ($p<0.05$) (Table 1).

Evaluation of dietary types in KTRs

The dietary intake data collected from the survey were compared with the recommended intake levels specified in the Dietary Pagoda of the Dietary Guidelines for Chinese Residents (2022 edition). Among the participants, the highest proportion meeting the recommended intake standards was observed for grains and potatoes (45.9%), followed by cooking oil (34.7%) and salt (28.6%). The proportion of individuals meeting recommended dairy intake was the lowest among all food groups, at only 2.04%; 60.2% of participants exceeded the recommended intake for cooking oil. Additionally, 55.1% of participants exceeded the recommended intake for salt (Table 2).

Food parameters stratified by waist circumference group

The food parameters of kidney transplant recipients in the abdominal obesity group and the non-abdominal obesity group were compared. There were statistically significant differences in energy, carbohydrates, dietary fiber, vitamin A, riboflavin, magnesium, iron and selenium between the non-abdominal obesity group and the abdominal obesity group ($p < 0.05$). The specific analysis is shown in Table 3.

Results of CHEI calculation

In the CHEI scoring system, food categories are assigned as 0, (0-2.5), (2.5-5), and 5. The scores for fruits, oils, and sodium, the scores are 0, (0-5), (5-10), and 10. Seventeen food groups were included in the CHEI assessment for KTRs. A maximum score (5 or 10) indicated that the participant met or exceeded the recommended intake levels according to dietary guidelines. Over 80% of KTRs met the recommended intake for poultry. Per dietary guidelines, more than 50% failed to meet the recommended intake for whole grains, potatoes, vegetables, dairy, legumes, fish and seafood, eggs, nuts, and fruits (Figure 1).

Logistic regression analysis of E-DII, CHEI, and abdominal obesity in KTRs

Binary logistic regression analysis revealed that the E-DII score is a risk factor for abdominal obesity in KTRs. Model 1 was unadjusted with an OR (95% CI) value of 3.05(1.20,7.75), $p = 0.019$. Model 2 adjusted for age and sex with an OR (95% CI) value of 3.69(1.35,10.1), $p =$

Table 1. Baseline characteristics stratified by waist circumference

Basic characteristics	All (n=98)	Non-abdominal obesity (n=64)	Abdominal obesity (n=34)	t/z/x^2	*p*
Sex				5.10	0.024*
Male	60 (61.2)	34 (53.1)	26 (76.5)		
Female	38 (38.8)	30 (46.9)	8 (23.5)		
Primary disease					
Glomerulonephritis	26 (26.5)	17 (26.6)	9 (26.5)	0.149	0.928
Hypertensive nephropathy	21 (21.4)	13 (20.3)	8 (23.5)		
Others	51 (52)	34 (53.1)	17 (50.0)		
Anthropometric parameters					
Diastolic pressure (mmHg) [median(IQR)]	80.00 (79.5,90.0)	80.00 (77.3,85.8)	86.50 (80.0,90.0)	2.19	0.029*
Grip (kg) (mean±SD)	23.7 ± 10.1	23.00 ± 9.89	25.1 ± 10.5	0.977	0.331
Pinch (kg) (mean±SD)	6.68 ± 2.12	6.47 ± 1.95	7.09 ± 2.38	1.38	0.171
Upper arm circumference (cm) [median(IQR)]	26.0 (24.0,28.0)	25.0 (23.0,26.5)	28.0 (26.0,30.0)	5.83	<0.001*
AMC (cm)[median(IQR)]	21.0 (18.7,22.8)	20.4 (18.2,22.5)	22.0 (20.1,23.6)	3.45	0.001*
Triceps skinfold thickness (mm) [median(IQR)]	16.7 (12.0,20.0)	15.0 (12.0,20.0)	18.0 (14.0,24.5)	2.46	0.014*
Waist circumference (cm)(mean±SD)	83.3 ± 11.6	76.5 ± 7.07	96.1 ± 6.12	13.7	< 0.001*
Weight (kg)[median(IQR)]	58.3 (49.9,67.9)	56.0 (48.1,60.0)	70.0 (64.8,75.3)	6.62	< 0.001*
Hip circumference (cm) [median(IQR)]	92.0 (88.0,97.1)	89.0 (86.0,92.0)	98.5 (95.4,104)	6.90	< 0.001*
Left calf circumference (cm) (mean±SD)	33.8 ± 3.35	32.5 ± 2.49	36.1 ± 3.54	5.78	< 0.001*
Right calf circumference (cm) (mean±SD)	33.8 ± 3.37	32.5 ± 2.55	36.2 ± 3.43	5.98	< 0.001*
Biochemical indicators					
BUN (mmol/L)[median(IQR)]	8.52 (7.07,12.1)	8.41 (6.94,12.0)	8.83 (7.12,12.7)	0.616	0.538
UA (mmol/L)(mean±SD)	363 ± 86.1	361 ± 10.6	365 ± 15.7	0.214	0.831
WBC ($10^{\wedge 9}$/L)[median(IQR)]	8.51 (6.70,10.6)	7.64 (6.34,9.91)	9.22 (7.48,11.1)	1.79	0.074
RBC ($10^{\wedge 12}$/L)[median(IQR)]	4.49 (4.11,5.03)	4.36 (3.97,4.82)	4.81 (4.35,5.41)	2.31	0.021*
MCV (fL)[median(IQR)]	88.1 (81.4,90.9)	88.1 (80.7,91.1)	87.0 (81.8,90.8)	0.398	0.690
Phase angle (°)[median(IQR)]	5.80 (5.19,6.73)	5.75 (5.03,6.80)	5.90 (5.20,6.70)	0.217	0.829
ALB (kDa)[median(IQR)]	44.2 (40.6,46.8)	44.1 (40.6,46.6)	44.3 (40.4,47.1)	0.142	0.888
ALT (U/L)[median(IQR)]	21.0 (15.8,29.3)	21.0 (15.3,29.0)	22.5 (16.5,30.5)	0.430	0.685
AST (U/L)[median(IQR)]	18.0 (15.0,22.0)	19.0 (16.0,22.0)	17.5 (14.0,21.0)	1.59	0.122
TG (mmol/L)[median(IQR)]	1.33 (0.93,2.27)	1.26 (0.82,1.82)	1.77 (1.03,2.69)	1.85	0.064

WBC: White blood cell; MCV: Erythrocyte mean corpuscular volume; TG: Triglyceride
**p* value <0.05

Table 1. Baseline characteristics stratified by waist circumference (cont.)

Basic characteristics	All (n=98)	Non-abdominal obesity (n=64)	Abdominal obesity (n=34)	t/z/x^2	*p*
Biochemical indicators					
Blood glucose (mmol/L) [median(IQR)]	4.70 (4.25,5.78)	4.60 (4.11,5.37)	5.08 (4.51,6.41)	2.05	0.040*
Urine pH (umol/L) [median(IQR)]	6.00 (5.50,6.50)	6.00 (5.50,6.50)	6.00 (5.50,6.50)	0.557	0.578
Parathyroid hormone (pg/mL) [median(IQR)]	88.9 (65.4,142)	85.7 (61.4,128)	112 (77.8,18)	1.47	0.140
Insulin (mIU/L)[median(IQR)]	10.5 (7.45,13.3)	8.95 (6.80,12.4)	11.9 (9.83,15.6)	2.74	0.006*
CO_2-CP (mean±SD)	22.3±3.39	22.90±3.89	21.4±3.21	2.16	0.033*
Calculation indicators					
BMI [median(IQR)]	22.0 (19.2,24.6)	20.1 (18.6,22.2)	25.1 (23.6,27.3)	6.37	<0.001*
E-DII [median(IQR)]	0.48 (-0.79,1.24)	0.13 (-0.90,1.01)	0.66 (-0.01,1.59)	2.13	0.033*
CHEI (mean±SD)	50.9±10.5	53.2±11.0	46.4±7.86	3.52	0.001*

WBC: White blood cell; MCV: Erythrocyte mean corpuscular volume; TG: Triglyceride
*p value <0.05.

Table 2. Evaluation of dietary types in KTRs

Types of food	Recommended quantity(g)	Compare with the recommended amount (%)			Compliance rate
		Lower than	Normal	Higher than	
Grain and potato	250~400	18.4	45.9	35.7	45.9
Vegetables	300~500	72.5	24.5	3.06	24.5
Fruits	200~350	75.5	21.4	2.9	21.4
Animal food	120-200	27.6	19.4	53.1	19.4
Dairy	300~500	96.9	2.04	0	2.04
Soybeans and nuts	25~35	88.8	4.08	6.12	4.08
Oil	25~30	5.10	34.7	60.20	34.7
Salt	<5	16.3	28.6	55.10	28.6

Table 3. Food parameters stratified by waist circumference group

Food parameters	All (n=98)	Non-abdominal obesity (n=64)	Abdominal obesity (n=34)	t/z	*p*
Energy (kcal)	1491 (1236,1781)	1558 (1275,1866)	1329 (1083,1638)	2.22	0.026*
Protein (g)	60.5 (44.2,79.6)	63.6 (48.3,84)	53.9 (35.7,68.1)	1.60	0.110
Fat (g)	67.8 (55.3,92)	68.7 (55.0,93.5)	64.8 (55.6,90.1)	0.552	0.581
Carbohydrates (g)	148 (109,193)	164 (126,201)	119 (78.7,166)	3.01	0.003*
Dietary fiber (g)	6.42 (3.69,10.19)	8.13 (4.10,11.37)	4.92 (2.86,6.80)	3.11	0.002*
Cholesterol (mg)	222 (133,456)	257 (144,525)	210 (99.5,343)	1.25	0.211
Vitamin A (μg)	93.3 (49.3,167)	112 (57.1,203)	79.1 (34.0,133)	2.09	0.037*
Vitamin B-1 (mg)	0.67 (0.33,1.03)	0.74 (0.39,1.01)	0.44 (0.23,1.16)	1.55	0.121
Riboflavin (mg)	0.66 (0.47,0.98)	0.72 (0.52,1.03)	0.57 (0.38,0.92)	2.28	0.023*
Niacin (mg)	16 (11.4,20.2)	16.5 (12.4,21.0)	12.4 (9.34,18.8)	1.47	0.141
Folic acid (μg)	120 (55.2,182)	123 (59.2,202)	92.6 (42.7,144)	1.55	0.122
vitamin C (mg)	23.6 (2.00,76.2)	32.9 (2.77,94.1)	16.6 (0.00,39.0)	1.81	0.070*
vitamin E (mg)	10.7 (7.52,15.5)	11.45 (7.90,17.2)	8.84 (6.67,14.3)	1.85	0.064
Carotene (μg)	540 (96.6,2320)	687 (156,2506)	399 (38.5,46.4)	1.70	0.090
vitamin B-6 (mg)	0.17 (0.08,0.33)	0.19 (0.07,0.36)	0.14 (0.08,0.26)	0.769	0.442
Magnesium (mg)	146 (95.1,199)	165 (108,226)	114 (83.2,162)	2.68	0.007*
Iron (mg)	12.6 (9.93,16.7)	13.4 (11,18.7)	11.1 (8.74,14.3)	2.54	0.011*
Zinc (mg)	4.19 ± 1.68	4.31 ± 1.63	3.95 ± 1.77	1.01	0.315
Selenium (μg)	5.72 (2.37,9.46)	6.36 (3.25,12.5)	3.23 (1.94,7.25)	2.82	0.005*
SFA (mg)	18.2 (14.0,24.3)	18.1 (14.3,13.2)	18.4 (13,26.9)	0.370	0.712
MUFA (mg)	21.2 (16.0,28.3)	21.6 (16.7,28.1)	19.1 (15.0,31.7)	0.325	0.745
PUFA (mg)	8.98 (5.41,14.9)	9.27 (5.67,16.4)	8.73 (4.68,12.9)	0.900	0.368

*$p<0.05$

Table 4. Logistic regression analysis of E-DII, CHEI, and abdominal obesity in KTRs

		Wald X^2	OR(95%CI)	*p*
E-DII	Model 1	5.51	3.05 (1.20,7.75)	0.019
	Model 2	6.49	3.69 (1.35,10.1)	0.011
	Model 3	5.52	3.51 (1.19,10.4)	0.023
CHEI	Model 1	8.61	0.889 (0.932,0.978)	0.003
	Model 2	6.56	0.939 (0.894,0.985)	0.010
	Model 3	6.02	0.939 (0.893,0.987)	0.014

Model 1: unadjusted, Model 2: adjusted the age and sex, Model 3: adjusted for age, sex, RBC, blood glucose and insulin

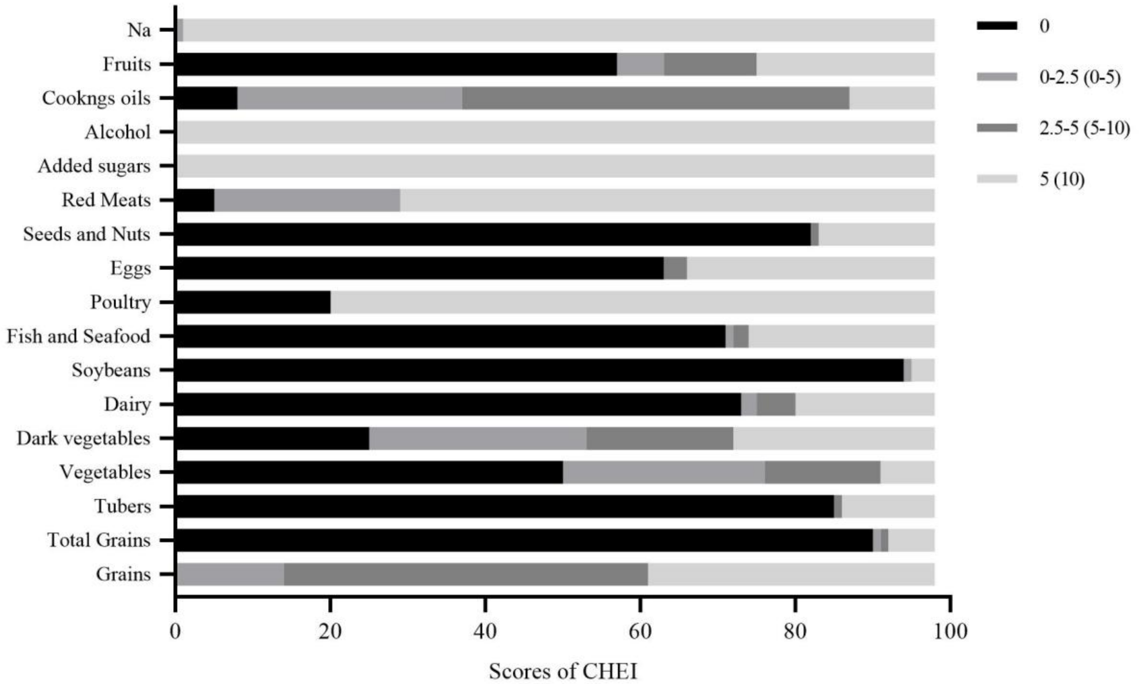

Figure 1. Proportion of CHEI scores in each food group of KTRs.

Table 5. E-DII and the risk of all-cause mortality in KTRs

		Wald X^2	OR(95%CI)	*p*
E-DII	Model 1	0.302	1.18 (0.654,2.13)	0.582
	Model 2	0.541	1.26 (0.685,2.30)	0.462
	Model 3	0.407	1.22 (0.659,2.27)	0.523

Model 1: unadjusted, Model 2: adjusted the age and sex, Model 3: adjusted for age, sex, RBC, blood glucose and insulin

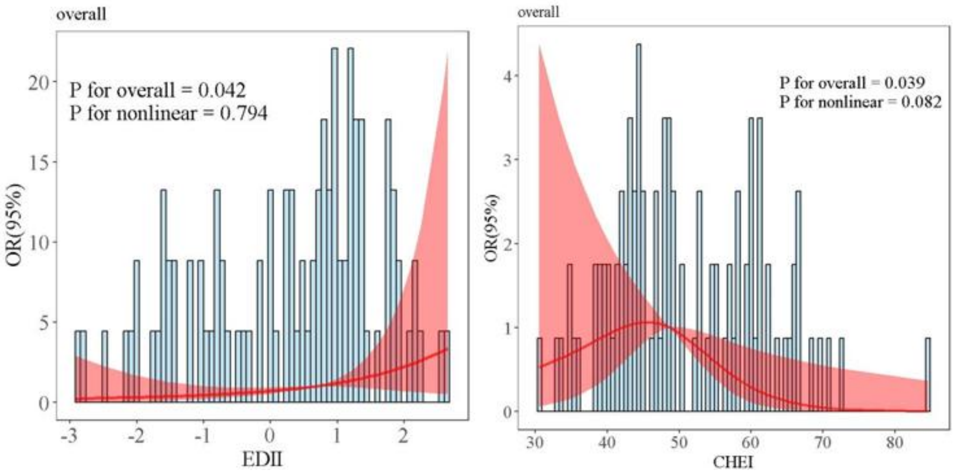

Figure 2. RCS analysis of the correlation between E-DII and CHEI and abdominal obesity in KTRs

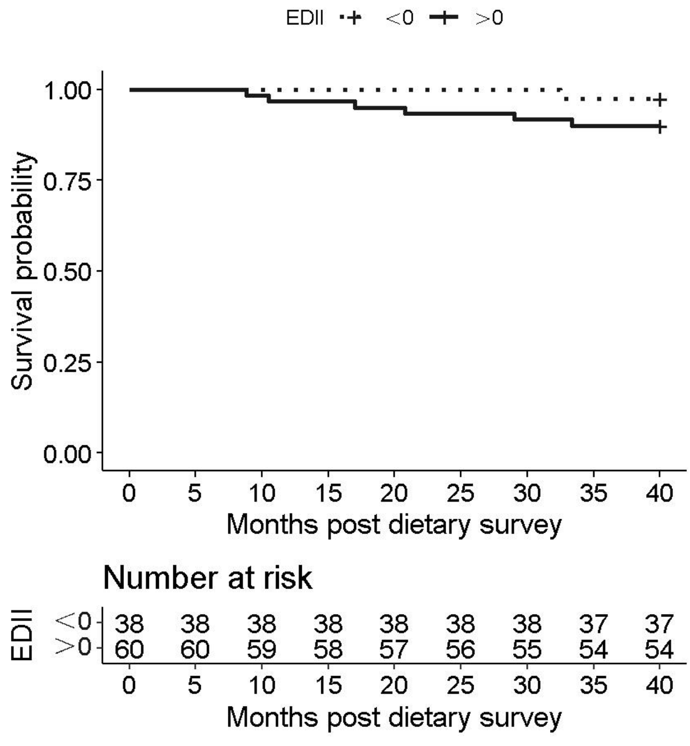

Figure 3. Comparison of all-cause mortality of KTRs between the two groups

0.011. Model 3 adjusted for adjusted for age, sex, RBC, blood glucose and insulin with an OR (95% CI) value of 3.51(1.19,10.4), *p* =0.023. The CHEI score is a protective factor for abdominal obesity in KTRs. Model 1 was unadjusted with an OR (95% CI) value of 0.889 (0.932, 0.978), *p* = 0.003. Model 2 adjusted for sex and age with an OR (95% CI) value of 0.939 (0.894,0.985), *p* = 0.010. Model 3 adjusted for adjusted for age, sex, RBC, blood glucose and insulin with an OR (95% CI) value of 0.939(0.893,0.987), *p* = 0.014 (Table 4).

Association between E-DII, CHEI scores, and abdominal obesity in KTRs

RCS analysis examined the associations between E-DII, CHEI scores, and abdominal obesity in KTRs. A positive association was observed between E-DII and abdominal obesity in KTRs (p for overall = 0.042, p for nonlinear =0.794), with a more pronounced upward trend when the E-DII value exceeded 1. A negative association was observed between the CHEI and abdominal obesity (p for overall = 0.039, p for nonlinear = 0.082), with a more pronounced downward trend when the CHEI value reached 48 (Figure 2).

Impact of pro-inflammatory diet on survival in KTRs

Cox regression analysis revealed no statistically significant association between the E-DII and all-cause mortality in KTRs [HR=0.407, 95%CI (0.659, 2.27), p = 0.523] (Table 5). Survival outcomes were compared between KTRs in the pro-inflammatory and anti-inflammatory groups. Kaplan-Meier survival analysis revealed no statistically significant difference between the two groups p = 0.176 ($p > 0.05$). However, the mortality rate in the pro-inflammatory group (10%) was 3.8 times higher than that in the anti-inflammatory group (2.63%) (Figure 3).

DISCUSSION

Abdominal obesity is a significant health concern and a well-established risk factor for non-communicable diseases.[16] KTRs frequently consume high-calorie diets to support post-surgical recovery. Concurrently, reduced physical activity levels and inadequate energy expenditure contribute to excess energy storage as fat, significantly elevating the risk of obesity.[17]

In this cross-sectional study, we examined the associations between the E-DII, CHEI, and the development of abdominal obesity by calculating these indices based on the dietary status of KTRs. The findings suggest significant associations between abdominal obesity in KTRs and both E-DII and CHEI scores. E-DII was identified as a risk factor for abdominal obesity in KTRs. The association remained significant even after adjusting for age, sex, RBC, blood glucose and insulin levels. CHEI may serve as a protective factor against abdominal obesity in KTRs. RCS analysis revealed a negative association was observed between CHEI and abdominal obesity when the CHEI value exceeded 48, with the downward trend transitioning from gradual to rapid. Follow-up analysis revealed no statistically significant difference in survival rates between the pro-inflammatory and anti-inflammatory groups. This lack of significance may be attributed to the small sample size; however, the mortality rate in the pro-inflammatory group was 3.8 times higher than in the anti-inflammatory group. As this is a cross-sectional study, our findings are limited to identifying associations rather than establishing causality. Further, longitudinal studies are needed to investigate the relationship between E-DII and abdominal obesity in KTRs.

KTRs must pay close attention to their diet, as their nutritional needs vary significantly at each stage.[18] A long-term pro-inflammatory diet causes KTRs to suffer from metabolic disorders, cardiovascular disease, and an increased risk of cancer.[19-21] A study involving 260 KTRs in Queensland, Australia, demonstrated that a pro-inflammatory diet increases the risk of skin squamous cell carcinoma in this population.[22] Similarly, a study conducted among Iranian KTRs found that adherence to a Mediterranean diet is associated with a lower risk of metabolic syndrome.[23] This protective effect may be attributed to the Mediterranean diet's emphasis on plant-based foods, healthy fats, and moderate consumption of animal products.[24] According to our study's KTRs' food intake analysis, the higher over consumption rate was observed for salt, at 55.10. Previous studies have shown that high salt intake is positively associated with adiposity and inflammation, which is closely linked to the development of obesity.[25] Conversely, vegetable intake was severely insufficient, with 72.5% of KTRs failing to meet the recommended levels. Dietary fiber, abundant in vegetables, is crucial in improving intestinal health, regulating blood sugar levels, and reducing abdominal fat accumulation.[26] This unbalanced dietary pattern harms weight control and prevents abdominal obesity.[27] While numerous studies have employed the DII in the general population, few have focused on KTRs. As a unique group, dietary management after transplantation is critical for the health of these patients and the long-term function of the transplanted kidney. The CHEI is a tool used to assess diet quality in the Chinese population.[28] Previous research has shown that a high quality diet assessed by CHEI is significantly associated with a reduced risk of developing metabolic syndrome in the general population.[29] In our study, CHEI was also linked to the development of abdominal obesity, even after adjusting for age, sex, RBC, blood glucose and insulin. From the perspective of CHEI scores, KTRs exhibited significant deficiencies in the intake of legumes, whole grains, potatoes, nuts, dairy products, fish, seafood, eggs, fruits, and vegetables. However, for KTRs, adherence to the Dietary Approaches to Stop Hypertension (DASH) diet, characterized by moderate consumption of fish, poultry, and nuts, along with abundant intake of vegetables, fruits, whole grains, and low-fat dairy products is associated with reduced risk of metabolic syndrome.[30] Therefore, providing KTRs with appropriate dietary guidance can help mitigate health risks and enhance their quality of life.

RCS enables a more authentic, flexible, and accurate revelation of the complex associations between continuous predictor variables and binary outcomes. When analyzing data containing continuous predictors with binary outcomes, RCS should be considered an extension of binary logistic regression.[31, 32] It can be employed to explore the nonlinear relationship between dietary variables and health outcomes.[33]The RCS analysis revealed a linear correlation between E-DII and abdominal obesity, showing an upward trend. This upward trend becomes more pronounced when the E-DII value exceeds 1. A dietary analysis based on the National Health and Nutrition Examination Survey (NHANES) in the United States found that DII is associated with all-cause mortality in adults with abdominal obesity, as well as in those who are overweight or obese.[34] Therefore, we should pay more attention to abdominal obesity in KTRs. Similarly, a linear relationship between CHEI and abdominal obesity was observed, with a declining trend that becomes more pronounced when the CHEI score exceeds 48. This finding aligns with research conducted in the general population of Hubei, China, which found a negative linear relationship between CHEI and abdominal obesity.[35] Therefore, KTRs should increase their consumption of vegetables, fruits, whole grains, rapeseed oil, nuts, fish, poultry, and eggs while reducing their intake of high-fat, high-sugar, fried foods and processed meats. In a word, they should aim to reduce E-DII and increase CHEI to prevent abdominal obesity.

Few studies have used E-DII to examine the relationship between dietary inflammation and mortality in KTRs. We divided KTRs into pro-inflammatory and anti-inflammatory diet groups and compared their survival rates. The difference was not statistically significant (p = 0.176). However, the mortality rate in the pro-inflammatory group was 3.8 times higher than that in the anti-inflammatory group. According to a dietary survey in Australia, a pro-inflammatory diet increases the risk of all-cause mortality.[36] As previously discussed, pro-inflammatory diets are associated with all-cause mortality in adults with abdominal obesity, as well as in those who are overweight or obese, based on data from the NHANES in the United States from 2007 to 2018.[34] We did not find a significant link between pro-inflammatory diets and mortality in KTRs, possibly due to the short follow-up period or small sample size. Therefore, further research is needed.

The mechanisms of DII to abdominal obesity in KTRs remain incompletely elucidated. Existing research indicates that high-DII diet, rich in saturated fats, refined sugars, and processed meats, can elevate postprandial plasma levels of lipopolysaccharide (LPS) and free fatty acids (FFA), leading to metabolic endotoxemia.[37] LPS and saturated FFAs bind to Toll-like receptor 4 (TLR4) on adipocytes and macrophages, recruiting the MyD88 adaptor protein. This rapidly activates the nuclear factor κB(NF-κB) signaling cascade,[38] leading to nuclear translocation of the NF-κB p65 subunit. Following nuclear translocation of the NF-κB p65 subunit, it upregulates the transcription of pro-inflammatory cytokine genes such as tumor necrosis factor-α (TNF-α), interleukin-6 (IL-6), and IL-1β, and induces the expression of inducible nitric oxide synthase (iNOS) and cyclooxygenase-2 (COX-2). This cascade elevates local and systemic inflammation, establishing a chronic low-grade inflammatory state. The inflammatory environment induces the polarization of adipose tissue macrophages into M1 type. This disrupts normal adipocyte lipid storage capacity, promoting the preferential expansion of visceral adipose tissue, which ultimately drives the development of abdominal obesity.[39]

The strength of this study lies in being the first to analyze the correlation between the E-DII and the CHEI about abdominal obesity in KTRs while also conducting follow-up surveys to assess their survival status. However, there are several limitations to this study. First, as this study incorporated both cross-sectional and follow-up designs, the association between E-DII, CHEI and abdominal obesity only reflects correlation and cannot determine the causal direction. Thus, prospective studies are needed to verify whether these findings can be generalized to a broader population of KTRs. During follow-up, despite telephone tracking efforts, 4.8% of participants were lost to follow-up, with 80% of those having abdominal obesity. This may underestimate the strength of the associations between E-DII, CHEI, and abdominal obesity. Second, recall bias and inaccuracies in estimating food quantities are inherent limitations of dietary surveys. Additionally, we did not account for KTRs' consumption of alcohol and sugar, which could introduce biases in the data analysis. Third, we calculated E-DII using only 22 of the 45 dietary parameters. While it is common for studies to compute DII with fewer than 45 parameters, some research suggests that the predictive ability of DII slightly decreases when fewer than 30 parameters are used.[40] Finally, the small sample size limits the generalizability of the findings to all KTRs.

Conclusion

In conclusion, we examined the E-DII, CHEI, and survival rates of 98 KTRs and found a strong correlation between the risk of abdominal obesity and increases in both E-DII and CHEI. The relationship between E-DII, CHEI, and abdominal obesity is linear, with E-DII showing a positive correlation and CHEI showing a negative correlation. Additionally, the mortality rate in the pro-inflammatory group was 3.8 times higher than that in the anti-inflammatory group. KTRs are advised to consume more anti-inflammatory foods, such as fruits, vegetables, whole grains, nuts, fish, poultry, and eggs while reducing their pro-inflammatory foods like high-fat, high-sugar, fried foods and processed meats. The results of our study could aid KTRs in managing dietary inflammation to create practical strategies for avoiding abdominal obesity, but more research is required.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURES

No competing interests are reported.

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