Original Article

Unfavorable dietary quality and overweight or obesity in kidney transplant recipients as judged by the Chinese diet balance index 2016 (DBI-16)

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Background and Objectives: Little is known the effects of dietary quality (DQ) on kidney transplantation (KTR). We explored the associations between DQ assessed by the Chinese Diet Balance Index 2016 (DBI-16) and overweight or obesity in KTR. **Methods and Study Design:** KTR aged 18-65 years from Guangdong Second Provincial General Hospital were participated in this cross-sectional study. Anthropometric measurements such as body weight, height, body mass index (BMI) and biochemical parameters were measured by standard methods. Dietary intake was assessed by 3-day, 24-hour food records and DQ by DBI-16. Logistic regression was used to estimate odds ratios (OR) and 95% confidence intervals (95% Cl) for leading to overweight in KTR by the components of DBI-16 and DQ scores. **Results:** 97 KTR were enrolled and divided into overweight group (BMI ≥24 kg/m^2, n=35) and non-overweight group (BMI <24 kg/m^2, n=62) in the study. Compared with non-overweight individuals, overweight individuals took excessive grains, cooking oils, salts and didn't meet the recommended levels of vegetable and fruit intake (p<0.05) assessed by DBI-16. The lower bound score (LBS) was positively associated with overweight (29.7±5.42) in KTR (LBS: OR: 1.099, 95% CI: 1.019-1.185, p=0.014), and the higher bound score (HBS) score was negatively related with overweight (16.0±4.85) in KTR (HBS: OR: 0.903, 95% CI: 0.822-0.992, p=0.034). Combination of LBS and HBS predicted the occurrence of overweight in KTR (AUC: 0.705, p<0.001). **Conclusions:** Unfavorable DQ, including overall excessive consumption, excessive intake of grains, cooking oils, salts and insufficient intake of vegetable and fruit, was significantly associated with the occurrence of overweight or obesity in KTR.

Key Words: kidney transplant, dietary quality, Chinese Diet Balance Index 2016, DBI-16, obesity

INTRODUCTION

Kidney transplantation is currently the optimal approach for renal replacement therapy. Compared with dialysis, it can lead to a better quality of life and improve patient prognosis. More evidence suggests that body composition may influence prognosis after transplantation.[1] Overweight and obesity are associated with an increased risk of metabolic disturbances and, consequently, hyperglycemia, hypertension, dyslipidemia, and high risk of cardiovascular diseases (CVD). The most common cause of allograft loss is the recipient death, secondary to CVD, with functioning graft.

Dietary intake is a modifiable lifestyle behavior closely associated with most noncommunicable diseases (NCD),[2] including CVD.[3] There has been an increasing interest in using specific indexes to evaluate the dietary quality and their effects on NCD, especially in some developed countries, such as the Healthy Eating Index (HEI) and the Diet Quality Index (DQI) developed for Americans,[4,5] and the Mediterranean Diet Score (MDS) used for the residents in Northern Europe.[6] Regarding the methods of HEI and DQI, the Chinese Dietary Balance Index 2016 (DBI-16) has been designed to assess the overall diet quality in the Chinese population,[7] according to the Dietary Guidelines (2016) for Chinese residents.[8] Although associations of DBI-16 with diabetes,[9] hypertension,[10] and cardiometabolic risk factors have been reported in previous cross-sectional studies among subgroups in China,[11] data on the relationship between DBI-16 and overweight or obesity among residents in kidney transplant recipients is inconclusive.

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In this cross-sectional study, we aimed to explore the associations between diet quality assessed by DBI-16 and the risk of overweight or obesity among KTR. To provide some evidence on further dietary intervention to manage and prevent overweight or obesity in KTR. To better explain the relationship between overall dietary quality and overweight or obesity in KTR, we explored the relationship between dietary quality and overweight or obesity in KTR by assessing dietary quality using the DBI-16.

METHODS

Study design and participants

In this cross-sectional analysis, measurements and questions were taken from stable renal transplant recipients in the outpatient clinic of the Organ Transplantation Department of Guangdong Second Provincial General Hospital between September 2021 and May 2022, and these participants were informed about the entire survey process and voluntarily signed an informed consent form to assess renal transplant recipients' diets according to the Dietary Balance Index 2016. The ethics committee approved the survey protocol, the instrument, and the procedure for obtaining informed consent (Approval Number: 202206501). Written informed consent was given by all participants. After excluding participants with missing dietary data or difficult or incredibly low or high energy intake levels (<800 or >4000 kcal), 97 subjects aged 18-65 years entered the final analysis (Figure 1).

Dietary data collection and food groups

The dietary intake of the subjects was recorded through the 3-d 24-h recall method at the individual level, and a food inventory was recorded at the household level over the same three-day period. For the 24-h recall, a trained interviewer recorded the consumption of all food in a face-to-face interview, combining subjects' self-reported values with the total household consumption. We recorded each food according to the food composition table. Alcohol beverages were not included in our study because kidney transplant recipients are a special group and because there was no sample of participants who consumed alcohol during the survey. Because there was insufficient data on the sugar used as a condiment, sugar was not included in our study.

Demographic characteristics and anthropometric parameters

A standardized questionnaire was used to collect the information on demographic characteristics and medical history, including age, sex, area, ethnic group, education level, family income, marital status, occupation status, physical activity, smoking or not, alcohol drinking or not, medical history of diabetes, hypertension, and dyslipidemia, use of medications and nutraceuticals.

Anthropometric parameters such as height, mid-upper arm circumference (MAC), triceps skinfold thickness (TSF), mid-upper arm muscle circumference (MAMC), left calf circumference, right calf circumference, waist circumference (WC), and hip circumference (HC) were determined by trained technicians, using calibrated instruments with standard protocols and recorded to the nearest 0.1 cm or 0.1 mm. MAMC was calculated by the formula: MAMC (cm) = MAC (cm) - 0.314 * TSF (mm). Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters.

Biochemistry parameters

All participants provided a 10-mL blood sample after an overnight fast of at least 10 hour collected by the nurse of organ transplantation clinic. Biochemistry parameters tests such as serum creatinine (Cr), blood urea nitrogen (BUN), uric acid (UA), blood glucose (Glu), serum triglyceride (TG), serum cholesterol (Chol), blood cell counts, serum potassium (K+), serum insulin were performed at the clinical laboratory department by standard methods in hospital.

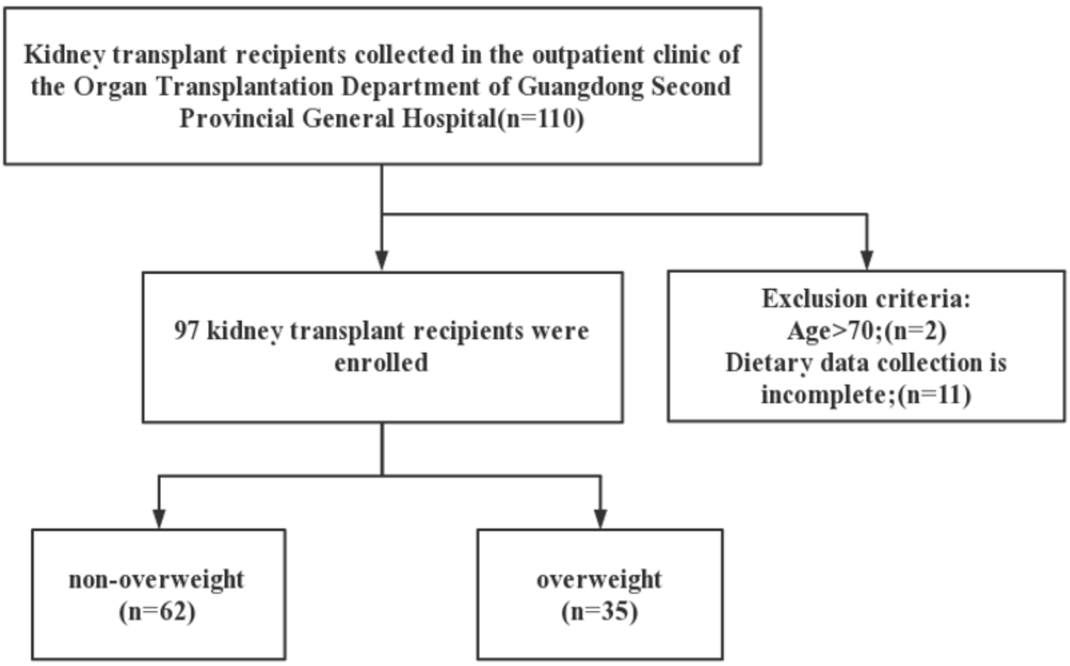

Figure 1. The flow chat of the included participants.

Diet Balance Index-2016

The purpose of the Chinese DBI-16 is to enable the assessment of overall dietary quality in the Chinese population. The DBI-16 has more specific energy assignment levels that can comprehensively reflect the dietary quality of the population; however, there are no differences in the main techniques and methods of evaluating the dietary quality of people. The DBI-16 has seven components from the Chinese Dietary Guideline(2016) and the Chinese Food Pagoda(2016),[8] namely (range of values): (1) cereals (−12-12); (2) vegetables (−6-0); fruits (−6-0); (3) milk and dairy products (−6-0), soybean and soybean products (−6-0); (4) animal foods (−4-4 for meat, -4-0 for fish, -4-4 for eggs); (5) empty energy food (0-6 for oil, 0-6 for alcohol); (6) condiments (0-6); and (7) diet variety (−12-0)7. A score of 0 is given when the food intake meets the recommendation of the dietary guidelines. The negative or positive scores indicate that recommended level is not met or is exceeded, respectively. The DBI-16 is further divided into 12 food subgroups, which are used to calculate the score for diet variety.[7]

Based on the scores for each DBI-16 component, their indicators of diet quality are calculated. Higher Bound Score (HBS),[7] the indicator for excessive food intake, is calculated by adding all the positive scores. Lower Bound Score (LBS),[7] the indicator for inadequate food intake, is computed by adding all the negative scores. Diet Quality Distance (DQD),[7] the indicator of imbalanced food intake, is calculated by the absolute values of both positive and negative scores.

Statistical analysis

Continuous variables were expressed as means and standard deviations (mean ± SD) and compared by using the Student's t-test. Categorical variables were presented as frequencies and percentages (n, %) and compared by using the Chi-square test. Logistic regression analysis were used to estimate odds ratios (OR) and 95% confidence intervals (95%Cl) for overweight by the components of DBI-16 and the indicators of diet quality. The level of statistical significance was defined as α = 0.05 of two-side probability. All analyses were performed using the IBM SPSS program (version 26, SPSS Inc., Chicago, IL USA), and all figures were performed by using GraphPad Prism software (version 8, GraphPad Prism, San Diego, CA, USA).

RESULTS

Participant characteristics

A total of 97 people in the study took health examination, bio-chemical indicators testing and completed questionnaires, including 62 men (63.9%) and 35 women (36.1%), aged 23 to 70, with a mean age (44.1±11.5 years). The overall prevalence of non-overweight (BMI<24) in this population was 63.9% (62/97), with the male was 54.8% and the female was 45.2%. The overall prevalence of overweight (BMI ≥24) in this population was 36.1% (35/97), with the male was 80% and the female was 20%. The characteristics according to participants non-overweight and overweight are shown in Table 1. Differences in gender, MAC, MAMC, TSF, WC, HC, waist-to-hip ratio, left calf circumference, right calf circumference, serum K^+, serum TG, blood glucose, red blood cells (RBC), hematocrit (HCT), and serum insulin were statistically significant in non-overweight and overweight groups ($p<0.05$) (Table 1).

Assessments of dietary quality

The distributions of scores for the DBI-16 components are presented in Table 2. Overall, 1.61% to 32.3% of participants have reached the recommended dietary intakes (score=0) of the DBI-16 components. Inadequate intakes (score<0) were most commonly observed in vegetables, fruits, dairy, soybeans and fish, with the corresponding proportions among all participants of 67.6%, 72.6%, 96.8%, 93.6%, and 71.0%, respectively. All individuals had a dietary variety below the recommended level. By contrast, excessive intakes (score>0) in cereals, meats, eggs, cooking oils, and salt were also observed among 90.3%, 87.1%, 40.3%, 93.6%, and 98.4% of participants, respectively. Participants who were overweight did not consume enough fruits and vegetables compared to those who were non-overweight. (p<0.05). And participants with non-overweight had a more excessive intake of cereals and salt than those overweight ($p<0.05$) (Table 2 and Table 3).

The DBI-16 also revealed that 37.1%, 56.5%, and 6.45% of participants had a low, moderate, and high level of under intake (indicated by LBS), respectively; 45.2% and 51.6% of them had a low to moderate level of over intake (indicated by HBS), respectively; 6.45%, 74.2%, and 19.4% of them had a low to the high-level problem of overall unbalance (indicated by DQD), respectively. Higher prevalence of moderate and high levels of inadequate intake in the overweight KTR compared to the non-overweight KTR. (LBS, 74.3%, 11.4%). Higher prevalence of moderate level of excess intake in the non-overweight compared to the overweight (HBS, 51.6%). Higher prevalence of moderate horizontal imbalance in the non-overweight compared to the overweight (DQD, 74.2%) (Table 4).

Association analyses of overweight with Dietary Quality Indicators

Logistic Regression analysis of dietary quality indicators and occurrence of overweight in KTR showed that LBS were significantly associated with the occurrence of overweight in KTR, and remained statistically significant after correction for sex, waist-to-hip ratio, K^+, TG, Glu, RBC, HCT, and HBS. The OR of all five models for LBS were greater than 1, indicating that LBS was a protective factor against the occurrence of overweight in KTR. Model 1 was uncorrected with an OR (95% CI) value of 1.099 (1.019-1.185), p=0.014. Model 2 adjusted for gender with an OR (95% CI) value of 1.112 (1.027-1.205), p=0.009. Model 3 adjusted for gender, waist-to-hip ratio with an OR (95% CI) value of 1.138 (1.029-1.259), p=0.012. Model 4 adjusted for sex, waist-to-hip ratio, K^+, TG, Glu, RBC, and HCT with an OR (95% CI) value of 1.140 (1.024-1.269), p=0.016. Model 5 adjusted for sex, waist-to-hip ratio, K^+, TG, Glu, RBC, HCT, and HBS with an OR (95% CI) value of 1.159 (1.029-1.305), p=0,015 (Figure 2).

Table 1. Baseline characteristics of participants according to BMI grouping

Characteristics	All (n=97)	Non-overweight (n=62)	Overweight (n=35)	*p* value
Gender (n, %)				0.029*
men	62.0 (63.9)	34.0 (54.8)	28.0 (80.0)	
women	35.0 (36.1)	28.0 (45.2)	7.00 (20.0)	
Age (n, %)				0.362
18~40	36.0 (37.1)	20.0 (32.3)	14.0 (40.0)	
41~60	53.0 (54.6)	38.0 (61.3)	17.0 (48.6)	
60~	8.00 (8.25)	4.00 (6.45)	4.00 (11.4)	
Primary disease (n, %)				0.846
Glomerulonephritis	26.0 (26.8)	17.0 (27.4)	9.00 (25.7)	
Hypertensive nephropathy	21.0 (21.7)	14.0 (22.6)	10.0 (28.6)	
Others	50.0 (47.4)	31.0 (50.0)	16.0 (45.7)	
Anthropometric parameters (mean±SD)				
Upper Arm Circumference (cm, mean±SD)	25.8±3.20	24.3±2.50	28.6±2.50	<0.001
Upper arm muscle circumference (cm, mean±SD)	20.5±3.10	19.6±3.30	22.1±2.20	<0.001
Triceps skinfold thickness (mm, mean±SD)	16.8±8.20	14.9±8.20	20.4±7.20	0.001*
Waist Circumference (cm, mean±SD)	83.7±11.4	77.7±7.90	94.5±8.20	<0.001
Hip circumference (cm, mean±SD)	93.3±7.30	89.7±4.70	99.8±6.50	<0.001
Waist-to-hip ratio (mean±SD)	0.90±0.10	0.90±0.10	1.00±0.10	<0.001
Left calf circumference (cm, mean±SD)	33.8±3.50	32.6±2.90	36.3±3.20	<0.001
Right calf circumference (cm, mean±SD)	33.8±3.50	32.5±2.80	36.4±3.20	<0.001
Biochemical indicators (mean±SD)				
Cr (umol/L, M (P25, P75))	120 (99.0, 145)	121 (101, 147)	118 (89.9, 154)	0.761
BUN (mmol/L, M (P25, P75))	8.31 (7.02, 12.4)	8.24 (6.91, 12.6)	8.38 (7.09, 12.1)	0.864
UA (mmol/L, mean±SD)	360±98.3	357±101	364.±93.2	0.772
K^+ (mmol/L, M (P25, P75))	4.12 (3.71, 4.40)	4.00 (3.66, 4.27)	4.26 (3.9, 4.51)	0.038*
TG (mmol/L, M (P25, P75))	1.33 (0.95, 2.30)	1.25 (0.86, 1.66)	1.77 (1.12, 2.64)	0.028*
Cholesterol (mmol/L, mean±SD)	5.50±1.40	5.40±1.30	5.50±1.50	0.809
Glu (mmol/L, M (P25, P75))	4.69 (4.21, 5.69)	4.54 (4.11, 5.36)	5.2 (4.52, 6.62)	0.022*
NEUT ($*10^9$, mean±SD)	5.80±2.80	5.50±2.70	6.50±3.00	0.108
RBC ($*10^{12}$, mean±SD)	4.60±1.00	4.50±0.900	4.90±0.90	0.048*
HCT (%, mean±SD)	0.40±0.10	0.400±0.100	0.40±0.10	0.014*
Insulin (mIU/L, M (P25, P75))	10.4 (7.45, 13.1)	8.10 (6.60, 12.3)	11.9 (10.1, 16.0)	0.001*

BMI: body mass index; SD: standard deviation; Cr: creatinine; BUN: blood urea nitrogen; UA: uric acid; TG: triglyceride; Glu: glucose; NEUT: neutrophil; RBC: Red blood cells; HCT: red blood cell specific volume.
**p* value <0.05.

Table 2. Distributions of scores for the DBI-16 components and the percentages of participants with each score

Components	Score range†	Group (BMI)	Distribution of Score												
			(−12)–(−11)	(−10)–(−9)	(−8)–(−7)	(−6)–(−5)	(−4)–(−3)	(−2)–(−1)	0	(1)–(2)	(3)–(4)	(5)–(6)	(7)–(8)	(9)–(10)	(11)–(12)
Cereals	(−12)–	<24						1.61	8.06	1.61	8.06	11.29	3.23	3.23	62.90
	(12)	≥24				5.71	2.86	2.86	11.4	5.71	2.86	2.86	2.86	5.71	57.14
Vegetables	(−6)–	<24				8.06	30.7	29.0	32.3						
	(0)	≥24				17.1	42.9	14.3	25.7						
Fruits	(−6)–	<24				51.6	11.3	9.68	27.4						
	(0)	≥24				77.1	8.57	8.57	5.71						
Dairy	(−6)–	<24				75.8	9.68	11.3	3.23						
	(0)	≥24				68.5	14.3	11.4	5.71						
Soybeans	(−6)–	<24				83.8	6.45	3.23	6.45						
	(0)	≥24				85.7	2.86	5.71	5.71						
Red meats/products, Poultry/game	(−4)–	<24					8.06	1.61	3.23	4.84	82.3				
	(4)	≥24					2.86	5.71	8.57	5.71	77.1				
Fish/shrimps	(−4)–	<24					51.6	19.4	29.0						
	(0)	≥24					57.1	14.3	28.6						
Eggs	(−4)–	<24					53.2	4.84	1.61	8.06	32.3				
	(4)	≥24					65.7	5.71	2.86	5.71	20				
Cooking oils	(0)–	<24							6.45	53.2	35.5	4.84			
	(6)	≥24							2.86	57.1	37.1	2.86			
Salt	(0)–	<24							1.61	74.2	22.6	1.61			
	(6)	≥24							2.86	82.9	8.57	5.71			
Diet variety	(−12)–	<24			4.84	43.6	45.2	6.45							
	(0)	≥24			2.86	65.7	25.7	5.71							

†Score range of total score is −60 to 44.
‡p value for chi-square test for the proportions of the scores for each food group.

Table 3. The comparison of component DBI-16 scores between the groups

	Non-overweight	Overweight	*p*
Cereals	9.11±4.31	7.71±6.18	0.014*
Vegetables	-1.93±1.76	-2.71±1.95	0.047*
Fruits	-3.61±2.67	-5.09±1.82	0.002*
Dairy	-5.15±1.64	-5.09±1.65	0.860
Soybeans	-5.61±1.50	-5.60±1.44	0.983
Red meats/products, Poultry/game	3.07±2.27	2.91±2.20	0.751
Fish/shrimps	-2.80±1.83	-2.86±1.83	0.890
Eggs	-0.90±3.72	-2.06±3.28	0.118
Cooking oils	2.30±1.17	2.40±1.12	0.669
Salt	1.95±0.78	1.63±0.73	0.049*
Diet variety	-4.52±1.23	-4.91±1.20	0.016*

*p-value <0.05.

Table 4. Distribution of dietary quality and the percentages of participants with each category

Diet Quality	Indicator	Score range	Group	Mean±SD	Distribution of Dietary Quality (%)†			
					Almost No Problem	Low Level Problem	Moderate Level Problem	High Level Problem
Under intake	LBS	0–60	Non-overweight	26.4±6.28	0	37.1	56.5	6.45
			Overweight	29.7±5.42	0	14.3	74.3	11.4
Over intake	HBS	0–44	Non-overweight	18.2±4.44	3.22	45.2	51.6	0
			Overweight	16.0±4.85	8.57	54.3	37.1	0
Overall unbalance	DQD	0–84	Non-overweight	44.6±6.82	0	6.45	74.2	19.4
			Overweight	45.7±7.86	0	2.86	60.0	37.1

† Distribution of the lower bound score (LBS): Almost no problem: 1–12; Low level: 13–24; Moderate level: 25–36; High level: 37–60. Distribution of the higher bound score (HBS): Almost no problem: 1–9; Low level: 10–18; Moderate level: 19–27; High level: 28–44. Distribution of the diet quality distance (DQD): Almost no problem: 1–17; Low level: 18–34; Moderate level: 35–50; High level: 51–84.

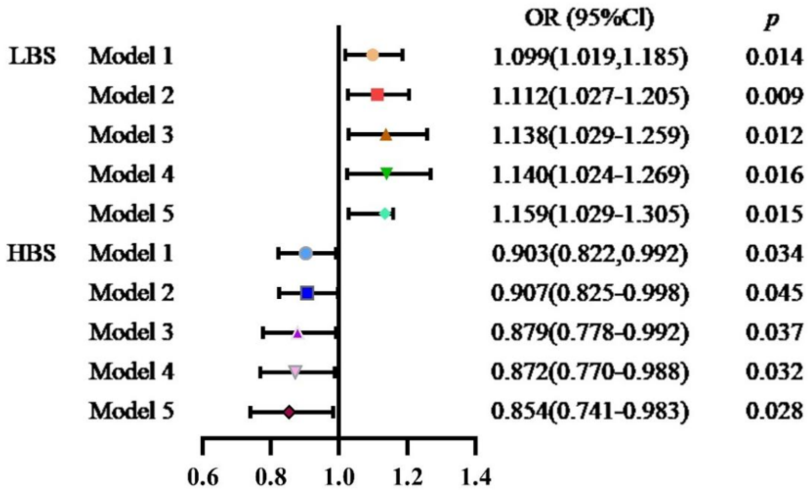

Figure 2. Odds ratios (ORs) and 95% confidence intervals (95%CIs) for overweight by diet quality indicators according to logistic regression models. LBS: Model 1 does not adjust, Model 2 adjusted the gender, Model 3 adjusted gender and waist-to-hip ratio, Model 4 adjusted gender, waist-to-hip ratio, K, TG, Glu, RBC, and HCT, Model 5 adjusted gender, waist-to-hip ratio, K, TG, Glu, RBC, HCT, and HBS. HBS: Model 1 does not adjust, Model 2 adjusted the gender, Model 3 adjusted gender and waist-to-hip ratio, Model 4 adjusted gender, waist-to-hip ratio, K, TG, Glu, RBC, and HCT, Model 5 adjusted gender, waist-to-hip ratio, K, TG, Glu, RBC, HCT, and LBS.

Logistic Regression analysis of dietary quality indicators and occurrence of overweight in renal transplant recipients showed that HBS were significantly associated with the occurrence of overweight in renal transplant recipients, and remained statistically significant after correction for sex, waist-to-hip ratio, K^+, TG, Glu, RBC, and HCT. The five models for HBS models all had OR values less than 1, indicating that HBS is a risk factor for the development of overweight in renal transplant recipients. Model 1 was uncorrected with an OR (95% CI) value of 0.903 (0.822,0.992), p=0.034. Model 2 adjusted for gender with an OR (95% CI) value of 0.907 (0.825-0.998), p=0.045. Model 3 adjusted for gender, waist-to-hip ratio (WHR) with an OR (95% CI) value of 0.879 (0.778-0.992), p=0.037. Model 4 adjusted for sex, WHR, K^+, TG, Glu, RBC, and HCT with an OR (95% CI) value of 0.872 (0.770-0.988), p=0.032. Model 5 adjusted for sex, waist-to-hip ratio, K^+, TG, Glu, RBC, HCT, and LBS with an OR (95% CI) value of 0.854 (0.741-0.983), p=0,028. (Figure 2).

Among them, regression analysis based on the scores of each component of the DBI-16 in KTR and the occurrence of overweight showed that the score of fruit intake was a protective factor for the occurrence of overweight in KTR. The OR (95% Cl) was 0.756 (0.616-0.927), p=0.007 (Figure 3).

In addition, the ROC curves of LBS and HBS on overweight or obesity were also done. It can be seen that LBS

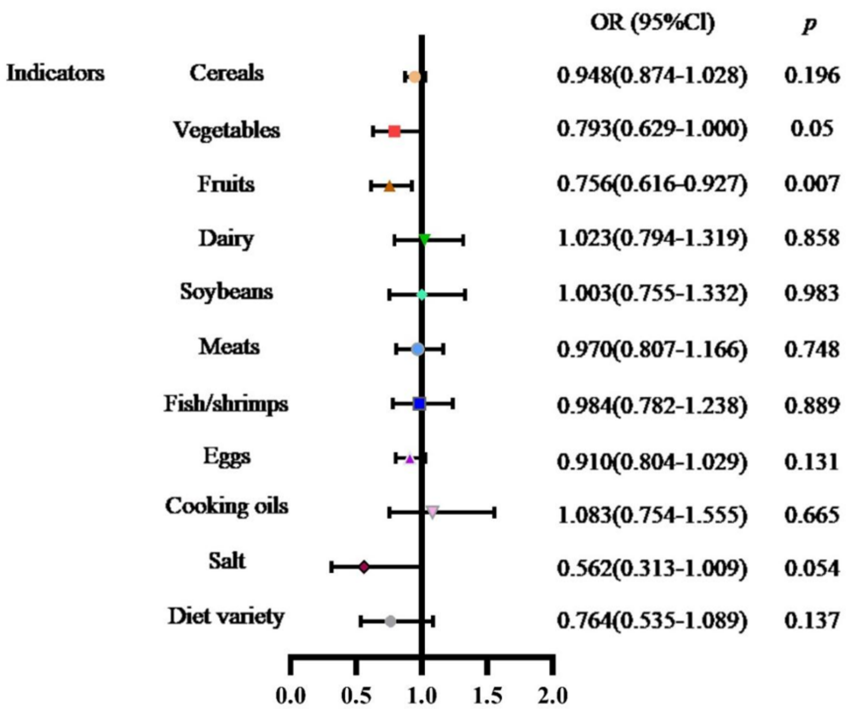

Figure 3. Odds ratios (ORs) and 95% confidence intervals (95%CIs) for overweight by DBI-16 components according to logistic regression models.

combined with HBS can predict the occurrence of overweight in KTR (AUC=0.705, *p*<0.001) (Figure 4).

DISCUSSION

Although there are many reports on dietary patterns and overweight or obesity, few studies have directly investigated the relationship between DBI-16 and risk factors for obesity or overweight in the renal transplantation population, and the available data in the Chinese population are very limited, especially in renal transplant recipients. In this cross-sectional survey conducted in kidney transplant recipients, we observed that participants faced varying degrees of dietary imbalance, mainly including inadequate intake of vegetables, fruits, dairy products, soy, fish, and eggs, and excessive intake of grains, meat, cooking oils, and salt (Table 2 and 3). Our analysis further suggests that unfavorable dietary quality, including LBS (29.7±5.42, OR: 1.099, 95% CI: 1.019-1.185, *p*=0.014) and HBS (16.0±4.85, OR: 0.903, 95% CI: 0.822-0.992, *p*=0.034), may be a risk factor and protective factor for the development of overweight or obesity in KTR. Even adjust by gender (model 2), gender + WHR (model 2) and gender + WHR + biochemistry parameters (model 4), these models also found that the LBS and HBS was the risk and protective factor of occurrence of overweight in KTR (Figure 2), respectively. The ROC curves of LBS combined with HBS on overweight or obesity were also done. It can be seen that LBS combined with HBS can predict the occurrence of overweight in kidney transplant recipients (AUC=0.705, *p*<0.001, Figure 4. However, it is noteworthy that our results found lower salt intake scores in overweight KTR than in non-overweight KTR. We consider that this is because overweight recipients increased their intake of other types of food, such as livestock and poultry meat, because they ate less salt; it is also possible that the amount of salt is difficult to estimate accurately and that recipients had recall errors during the dietary survey.

Obese patients after kidney transplantation have metabolic derangements, and obesity directly impacts most transplantation outcomes. Furthermore, obesity is synergic to some immunosuppressive agents in triggering diabetes and hypertension.[12] In a cohort study of 183 KTR, the high prevalence of overweight and the association between worsening graft function and high BMI in the short term after transplantation were described.[13] Previous studies show the high prevalence of obesity in KTR. Johnson et al observed that up to 50% of KTR gained more than 10% body weight during the first year after kidney transplantation.[14] Armstrong et al found that 21% of KTR had obesity after 7 years of transplantation.[15] Obesity is an ineffective prognostic factor in KTR and may be involved in the adverse cardiovascular outcomes, progression of proteinuria, graft failure, and acute rejection.[16] Appropriate dietary advice may enable the development of targeted strategies for treating obese KTR.

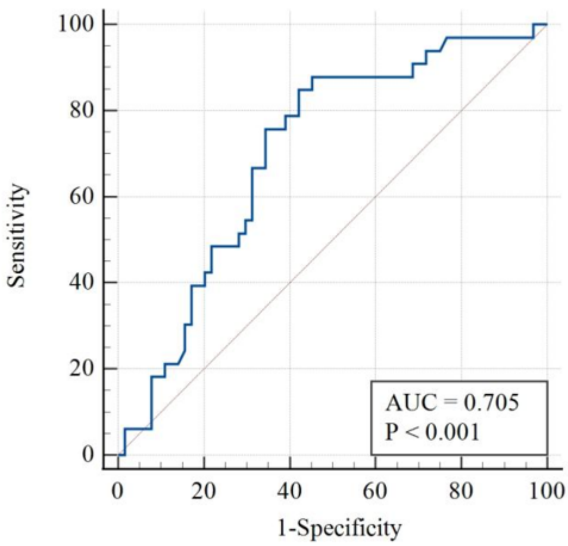

Figure 4. ROC of LBS and HBS. ROC: receiver operating characteristic; LBS: higher bound score; HBS: lower bound score.

DBI-16 is a good indicator for assessing dietary quality in the general population and diet-related health conditions,[17,18] such as risk factors for diabetes,[19] ischemic stroke and anemia.[20,21] Our results suggest that monitoring dietary diversity based on DBI-16 may be a useful method for evaluating the risk of obesity in KTR. Among the kidney transplant recipients we surveyed, the intake of cereals, meat, eggs, cooking oil, and salt was severely excessive, and the intake of vegetables, fruits, dairy, soybeans, and fish did not reach the recommended levels (Table 2). The intake of vegetables, fruits, dairy, and soybeans in overweight KTR is also significantly lower than that of non-overweight KTR (Table 3). The scores of each component of the DBI-16 in KTR and the occurrence of overweight showed that the score of fruit intake was a protective factor for the occurrence of overweight in KTR. The OR (95% Cl) was 0.756 (0.616-0.927), *p*=0.007 (Figure 3). In the correlation analysis, the indices of combined positive and negative end scores were risk and protective factors for overweight and obesity in renal transplant recipients, indicating that dietary imbalance was associated with the development of overweight and obesity in renal transplant recipients, and the effect of confounding factors was excluded. There are few studies of renal transplant dietary structure and obesity for our cross-sectional comparison, which requires additional relevant cohort studies to validate the results we found. However, we found some studies that used similar dietary quality scores. Oldewage-Theron and Egal asserted that adult women in South Africa had significantly higher BMI with lower DDS.[22] Azadbakht and Esmaillzadeh showed that Iranian female youth with higher DDS had lower abdominal adiposity and obesity.[23] All of these studies have shown that imbalanced diets increase the risk of obesity and overweight. This is consistent with the results we found. Another notable result of this study is that our obese KTR seem not to have followed the recommendations in the food guide. Some evidence indicates an association between food guide adherence and overweight. So et al. reported that Canadian adults who followed Canada's food guide recommendations, especially regarding the minimum servings of vegetables and fruits, had a lower prevalence of overweight or obesity and BMI.[24] A cross-sectional study from Australia also showed that low compliance with dietary guidelines was related to an approximately three-fold higher risk of being obese.[25] Our results showed that eating a variety and adequate amount of food, such as vegetables (which are low-energy-density foods), does not add substantial energy to the overall caloric intake in the diet and results in favorable weight status.

Our study has several strengths and limitations. First, to our knowledge, this is the first study to examine the relationship between dietary balance indices and the risk of overweight in KTR. However, causality cannot be inferred from the results because of its cross-sectional nature; further well-designed prospective studies and randomized controlled trials are warranted to determine whether the present findings are generalizable to other populations of KTR. Second, due to the specificity of the kidney transplant recipient population, we have a small sample size, which will continue to be included in stable kidney transplant recipients with follow-up over time. Third, the contribution of dietary balance indices to the metabolic risk of KTR may be dependent on food composition. Fourth, although this was not a randomized controlled trial, our results were analyzed using reliable laboratory data, epidemiological methods, and various comprehensive tools and measures (3-day dietary records with 24 h recall) to determine dietary quality. These methods have been used to assess the dietary intake of KTR, examine their nutrition-related problems,[26,27] and raise awareness about their nutritional status and CVD risk. Finally, the results are not generalizable to other areas of the world where the diet may be different, and the small sample size precluded the examination of the interactions between nutrients.

Conclusions

This is an observational study of dietary quality and overweight in kidney transplant recipients, and our results suggest a role of unfavorable dietary quality based on the DBI-16 score on overweight in kidney transplant recipient. The unfavorable dietary quality including overall excessive consumption, excessive intake of grains, cooking oils, salts and insufficient intake of vegetable and fruits may be the risk of overweight in KTR. The individuals who received renal transplantation should reduce the intake of grains, cooking oils, salts and increase the intake of vegetable and fruits. Further experimental and cohort studies are needed to reveal the causal relationship.

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AUTHOR DISCLOSURES

No competing interests are reported.

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