



# Dietary Compliance Among Renal Transplant Recipients: A Single-Center Study in Taiwan

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## ABSTRACT

**Background.** Extensive food and lifestyle changes are the major issues in renal transplant recipients (RTRs). Poor adherence to diet can contribute to increased health problems such as obesity, cardiovascular disease, and graft failure; however, comparative data regarding dietary compliance with the national recommendations has rarely been investigated, especially among RTRs in Taiwan.

**Methods.** In this descriptive analytical study, we compared patients' reported dietary intake of macronutrients and micronutrients with evidence-based guidelines developed for the nutritional management of adult kidney transplant recipients (NMAKTR) by the Dietitians Association of Australia. A total of 90 maintenance-phase RTRs were recruited from September 2016 to June 2018. All patients completed a 3-day dietary record (2 weekdays and 1 day on the weekend). In addition, routine anthropometric and laboratory data were obtained.

**Results.** The mean age, post-transplant years, and estimated glomerular filtration rate of participants were  $49.7 \pm 12.5$  years,  $9.1 \pm 6.1$  years, and  $55.5 \pm 20.8$  mL/min/1.73 m<sup>2</sup>, respectively. Daily energy and protein intakes were  $1869.1 \pm 383.5$  kcal ( $30.4 \pm 7.2$  kcal/kg/d) and  $66.9 \pm 14.4$  g ( $1.1 \pm .2$  g/kg/d), respectively. The percentage of energy intake from fat and saturated fat exceeded recommendations, whereas dietary fibers and calcium remained less than the recommended levels. At our center, a large percentage of RTRs did not meet NMAKTR dietary recommendations.

**Conclusion.** The low degree of dietary compliance calls for a continued effort to deliver effective nutritional advice in this population.

**R**ENAL transplant is an optimal treatment in patients with end-stage renal disease. Compared to dialysis patients, quality of life was improved [1], including correction of uremic toxins to increase dietary satisfaction and improve metabolic abnormalities. Obesity is a common phenomenon after transplant and is cross-linked with some nutrition-related metabolic side effects observed in successful renal transplant recipients (RTRs) [2,3]. Recent studies suggested that eating a healthy diet encompasses a variety of macronutrients and micronutrients that are acknowledged to prevent renal deterioration [4,5] and also

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**Table 1. Demographics and Characteristics in Renal Transplant Recipients**

	All (N = 90)	BMI Normal (n = 44)	BMI OBOV (n = 46)
<b>Characteristics</b>			
Male, n (%)	48 (53.3)	20 (45.5)	28 (60.9)
Age, y	49.7 ± 12.5	48.3 ± 14.2	51.0 ± 10.6
RT, y	9.1 ± 6.1	8.3 ± 6.3	9.9 ± 5.8
BH, cm	161.4 ± 8.5	160.6 ± 7.5	162.3 ± 9.4
BW, kg	63.2 ± 13.3	54.1 ± 8.0	72.0 ± 11.2*
BMI, kg/m <sup>2</sup>	24.1 ± 3.9	20.9 ± 2.1	27.2 ± 2.3*
WC, cm	83.3 ± 9.4	76.4 ± 6.2	89.7 ± 7.2*
<b>Renal source</b>			
Cadaveric, n (%)	75 (83.3)	38 (86.4)	37 (80.4)
Living donor, n (%)	15 (16.7)	6 (13.6)	9 (19.6)
<b>Body composition</b>			
VFA, kg	9.9 ± 8.4	6.6 ± 10.7	12.8 ± 4.1*
TBF, %	27.0 ± 7.0	23.9 ± 7.0	30.0 ± 5.7*
Total muscle mass, %	27.8 ± 4.0	28.5 ± 4.0	27.1 ± 3.9
<b>Laboratory data</b>			
Alb, g/dL	4.3 ± .3	4.4 ± .3	4.3 ± .3
BUN, mg/dL	24.3 ± 12.1	26.5 ± 15.1	22.2 ± 7.9
Cr, g/dL	1.4 ± .7	1.5 ± .9	1.4 ± .5
GFR, mL/min/1.73 m <sup>2</sup>	55.5 ± 20.8	54.8 ± 22.5	56.1 ± 19.2
Glucose (AC), mg/dL	100.3 ± 20.7	98.0 ± 19.0	102.5 ± 22.1
HbA1c, %	6.0 ± 1.0	5.9 ± 1.2	6.2 ± .8
Hs-CRP, mg/L	5.0 ± 11.9	3.2 ± 4.6	6.8 ± 15.9*
iPTH, pg/mL	116.1 ± 129.1	143.8 ± 172.2	91.5 ± 65.5
HDL-C, mg/dL	51.8 ± 17.5	54.6 ± 19.7	49.1 ± 14.8
LDL-C, mg/dL	121.4 ± 37.0	114.0 ± 41.3	128.5 ± 31.3*
TC, mg/dL	207.3 ± 44.6	203.3 ± 49.3	211.2 ± 39.8
TG, mg/dL	155.3 ± 119.3	133.6 ± 94.4	176.2 ± 136.8*
Insulin, uU/mL	8.4 ± 12.7	6.2 ± 3.1	10.6 ± 17.3*
HOMA-IR	2.3 ± 4.8	1.5 ± 1.3	3.1 ± 6.5*
UA, mg	6.2 ± 1.3	6.1 ± 1.3	6.3 ± 1.3

Data are expressed as mean ± standard deviation and number (%) as appropriate. Statistical analyses were conducted using the Student's *t*-test or the Wilcoxon rank-sum test as appropriate.

Abbreviations: AC, before meals; Alb, albumin; BH, body height; BMI, body mass index; BUN, blood urea nitrogen; BW, body weight; Cr, creatinine; GFR, glomerular filtration rate; HbA1c, hemoglobin A1c; HDL-C, high-density lipoprotein cholesterol; HOMA-IR, homeostatic model assessment of insulin resistance; Hs-CRP, high-sensitivity C-reactive protein; iPTH, intact parathyroid hormone; LDL-C, low-density lipoprotein cholesterol; RT, renal transplant; TBF, total body fat; TC, total cholesterol; TG, triglyceride; UA, uric acid; VFA, visceral fat; WC, waist circumference.

\**P* < .05.

are associated with better management of metabolic risk factors [6,7]. However, relatively few studies have investigated dietary quality and compliance with guidelines among RTRs, except 2009 guidelines for the nutritional management of adult kidney transplant recipients [8] suggested in Western countries. No medical nutrition therapy and dietary standards for RTRs have been established in Taiwan. The aim of this study, which was conducted at a single center in Taoyuan, Taiwan, was to analyze RTRs' dietary intake of macro- and micronutrients together with body mass index (BMI) classifications and compliance compared to evidence-based guidelines for adult RTRs worldwide.

## MATERIAL AND METHODS

### Study Design

Stable RTRs were recruited during routine clinical follow-ups from September 2016 to June 2018 in this cross-sectional study. Inclusion criteria were adults (individuals aged >18 years) who were RTRs with a functioning allograft for at least 1 year after transplant. Body weight (BW) changes greater than 3 kg, acute rejection with a glomerular

filtration rate (GFR) variation of up to 25% [9], missing laboratory data, and other systemic inflammatory disease were exclusion criteria, as previously described [10]. Written informed consent was obtained from each RTR, and the study protocol was approved by the Chang Gung Medical Foundation Institutional Review Board (IRB 201600954B0). According to the BMI classification of the Taiwan Ministry of Health and Welfare [11], RTRs were divided into 2 groups: those with a BMI less than 24 kg/m<sup>2</sup> comprised the normal group (BMI normal group) and those with a BMI greater than or equal to 24 kg/m<sup>2</sup> comprised the obese and overweight group (OBOV group).

### Data Collection

**Characteristics.** Demographic data obtained from the patients' medical records included age, gender, history of dialysis, height, and weight. Transplant duration was defined as years between dialysis and the beginning of transplant. Body composition and waist circumference were measured by bioelectrical impedance analysis with Omron scales (HBF-375; Omron Healthcare, Kyoto, Japan) with patients fasting at least 8 hours and wearing indoor clothing. BMI was calculated for each patient as the body mass divided by height in meters squared (kg/m<sup>2</sup>).

**Table 2. Dietary Intake of Macronutrients and Micronutrients in Renal Transplant Recipients**

Items and Groups	Daily Intake		
	All (N = 90)	BMI Normal (n = 44)	BMI OBOV (n = 46)
Dietary calorie, kcal	1869.1 ± 383.5	1775.1 ± 344.0	1959.0 ± 401.1*
kcal/kg BW	30.4 ± 7.2	33.3 ± 7.3	27.6 ± 6.0*
Dietary protein, g	66.9 ± 14.4	63.3 ± 14.5	70.3 ± 13.6*
Protein density, g/kg BW	1.1 ± .3	1.2 ± 0.3	1.0 ± 0.2*
Dietary carbohydrates, g	208.2 ± 51.0	200.1 ± 43.4	216.0 ± 56.7
Fiber, g	13.2 ± 5.2	12.9 ± 4.7	13.5 ± 5.7
Total dietary fat, % of energy	40.6 ± 5.8	40.3 ± 5.2	41.0 ± 6.3
SFA, % of energy	9.5 ± 2.7	9.4 ± 2.4	9.7 ± 3.0
MUFA, % of energy	13.2 ± 3.5	13.1 ± 3.7	13.3 ± 3.3
PUFA, % of energy	13.1 ± 4.8	13.2 ± 4.6	13.0 ± 5.1
n-3 PUFA, g	3.4 ± 1.7	3.2 ± 1.3	3.6 ± 1.9
n-3 PUFA, % of energy	1.6 ± .7	1.6 ± 0.6	1.7 ± 0.8
ALA, g	2.6 ± 1.3	2.4 ± 1.2	2.8 ± 1.4
EPA, g	.22 ± .30	.21 ± .28	.22 ± .32
DHA, g	.39 ± .47	.38 ± .44	.40 ± .51
n-6 PUFA, g	23.9 ± 10.0	22.9 ± 9.3	24.7 ± 10.7
n-6 PUFA, % of energy	11.5 ± 4.4	11.6 ± 4.3	11.4 ± 4.5
Cholesterol, mg	268.1 ± 120.6	251.4 ± 117.7	284.2 ± 122.4
<b>Vitamins</b>			
Vitamin A, µg RE	805.2 ± 388.9	815.5 ± 365.3	795.4 ± 413.9
Vitamin E, mg α-TE	31.7 ± 14.5	30.1 ± 12.7	33.3 ± 16.1
Vitamin C, mg	101.2 ± 61.0	95.8 ± 59.0	106.3 ± 63.0
Vitamin B1, mg	1.0 ± .3	1.0 ± .3	1.1 ± .3
Vitamin B2, mg	.9 ± .3	.9 ± .3	.9 ± .3
Niacin, mg NE	12.3 ± 4.0	11.9 ± 3.8	12.6 ± 4.3
Vitamin B6, mg	1.3 ± .3	1.2 ± .3	1.3 ± .4
Vitamin B12, µg	3.0 ± 2.1	3.2 ± 2.2	2.9 ± 2.0
Folic acid, µg	209.0 ± 97.9	216.8 ± 106.6	201.6 ± 89.4
<b>Minerals</b>			
Sodium, mg	1092.9 ± 768.5	1071.0 ± 720.5	1113.8 ± 819.2
Potassium, mg	1924.6 ± 516.9	1884.1 ± 552.1	1963.3 ± 483.7
Calcium, mg	367.1 ± 156.4	369.3 ± 157.7	364.9 ± 156.8
Magnesium, mg	201.2 ± 63.8	202.4 ± 67.6	200.2 ± 60.6
Phosphorus, mg	774.6 ± 194.1	765.8 ± 208.1	783.0 ± 181.6
Iron, mg	8.9 ± 2.5	8.7 ± 2.4	9.2 ± 2.6
Zinc, mg	8.6 ± 2.5	8.3 ± 2.1	8.9 ± 2.9

Data are expressed as mean ± standard deviation. Statistical analyses were conducted using the Student's *t*-test or the Wilcoxon rank-sum test as appropriate. Abbreviations: ALA, α-linolenic acid; BMI, body mass index; BW, body weight; DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid; RE, retinol equivalents; SFA, saturated fatty acid; α-TE, α-tocopherol equivalents.

\**P* < .05.

**Laboratory Data.** Serum creatinine (mg/dL), glucose (mg/dL), total cholesterol (mg/dL), triglycerides (mg/dL), low-density lipoprotein cholesterol (mg/dL), uric acid (mg), albumin (g/dL), high-sensitivity C-reactive protein (hs-CRP) (mg/L), and insulin (insulin units [uU]/mL) were measured at the hospital laboratory by standardized methods described previously [10]. The homeostatic model assessment of insulin resistance (HOMA-IR) was calculated using the following formula [12]: HOMA-IR = fasting insulin (µU/mL) × fasting glucose (mmol/L)/22.5.

**Dietary Intake Analyses and Recommendations.** After regular clinic visits, all of the eligible RTRs completed 3-day dietary records (2 weekdays and 1 day on the weekend) with measurements done using common household utensils. The dietary record was also rechecked by well-trained dietitians using food picture books to guarantee the accuracy of food portions. Macro- and micronutrients were calculated on the basis of a Taiwanese food composition table as the nutrient database (Taipei, Taiwan) by using the nutritionist edition of CofitPro version 1.0.0 (Cofit HealthCare Inc., Taipei,

Taiwan). In addition, sodium was calculated for food without additional seasoning in cooking or from the table.

All the nutrient analysis data were compared with the nutritional management of adult kidney transplant recipients (NMAKTR) [8] reference guideline published by the Dietitians Association of Australia in 2009. In order to comprehensively compare all the obtained dietary data from RTRs for certain nutrients not covered by the current dietary guidelines, we relied on some renal-specific or normal dietary reference values derived from the Kidney Disease Outcomes Quality Initiative published by National Kidney Foundation (2000 and 2003) [13,14], the European Best Practice Guideline (EBPG) on Nutrition (2007) [15], and dietary reference intakes (DRIs) published by the Taiwan Ministry of Health and Welfare (2011) [16].

#### Statistical Analyses

Statistical analyses were performed using SAS version 9.4 software (SAS Institute, Cary, NC, United States). Data were expressed as

**Table 3. Dietary Nutrient Intake and Proportions in Renal Transplant Recipients Needed to Meet Guideline Recommendations**

Items and Groups	Daily Intake			Guideline Recommendations
	All (N = 90), n (%)	BMI Normal (n = 44), n (%)	BMI OBOV (n = 46), n (%)	
Number	90	44	46	
Dietary calorie, kcal	59 (73.3)	30 (77.3)	29 (69.6)	M: 1700–1850 kcal* F: 1400–1450 kcal*
Protein density, g/kg BW	78 (86.7)	40 (90.9)	38 (82.6)	Stable: M: .84 g/kg/d; F: .75 g/kg/d <sup>†</sup>
Fiber, g	1 (1.1)	0 (0)	1 (2.2)	M: 30; F: 25 <sup>†</sup>
Total dietary fat, % of energy	17 (18.9)	6 (13.6)	11 (23.9)	25–35 <sup>‡</sup>
SFA, % of energy	27 (30)	13 (29.6)	14 (30.4)	≤8 <sup>‡</sup>
MUFA, % of energy	85 (94.4)	41 (93.2)	44 (95.7)	≤20 <sup>‡</sup>
PUFA, % of energy	26 (28.9)	11 (25)	15 (32.6)	≤10 <sup>‡</sup>
ALA, g	61 (67.8)	28 (63.6)	33 (71.7)	Plant sources: 2/d <sup>‡</sup>
n-6 PUFA, % of energy	12 (13.3)	4 (9.1)	8 (17.4)	8–10 <sup>‡</sup>
Cholesterol, mg	30 (33.3)	18 (40.9)	12 (26.1)	<200 <sup>‡</sup>
<b>Vitamins</b>				
Vitamin A, µg RE	25 (27.8)	16 (36.4)	9 (19.6)	700–900 <sup>§</sup>
Vitamin E, mg α-TE	84 (93.3)	41 (93.2)	43 (93.5)	12*
Vitamin C, mg	39 (43.3)	18 (40.9)	21 (45.7)	100*
Vitamin B1, mg	37 (41.1)	14 (31.8)	23 (50)	M: 1.2; F: .9*
Vitamin B2, mg	13 (14.4)	7 (15.9)	6 (13.0)	M: 1.3; F: 1.0*
Niacin, mg NE	22 (24.4)	7 (15.9)	15 (32.6)	M: 16; F: 14*
Vitamin B6, mg	16 (17.8)	6 (13.6)	10 (21.7)	1.5 (<51 y old); 1.6 (≥51 y old)*
Vitamin B12, µg	48 (53.3)	25 (56.8)	23 (50)	2.4*
Folic acid, µg	5 (5.6)	3 (6.8)	2 (4.4)	400*
<b>Minerals</b>				
Sodium, mg	8 (87.8)	5 (11.4)	3 (6.5)	80–100 mmol/d (1840–2300) <sup>†</sup>
Potassium, mg	32 (35.6)	14 (31.8)	18 (39.1)	50–70 mmol (1950–2730); 1 mmol/kg IBW <sup>§</sup>
Calcium, mg	1 (1.1)	1 (2.3)	0 (0)	1000/d; post-menopause: 1300/d <sup>†</sup>
Magnesium, mg	4 (4.4)	2 (4.6)	2 (4.4)	19–50 y old: M: 380; F: 320*; 51–70 y old: M: 360; F: 310*
Phosphorus, mg	28 (31.1)	10 (22.7)	18 (39.1)	800–1000 <sup>§</sup>
Iron, mg	32 (35.6)	13 (29.6)	19 (41.3)	M: 8; F: 15 <sup>§</sup>
Zinc, mg	29 (32.2)	13 (29.6)	16 (34.8)	M: 10–15; F: 8–12 <sup>§</sup>

Data are expressed as number (percent).

Abbreviations: ALA, α-linolenic acid; BMI, body mass index; BW, body weight; F, female; IBW, ideal body weight; M, male; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid; SFA, saturated fatty acid.

\*Target values recommended by Taiwan Ministry of Health and Welfare for dietary reference intakes

<sup>†</sup>Target values recommended by Dietitian Association Australia on Nutritional Management of Adult Kidney Transplant Recipients.

<sup>‡</sup>Target values recommended by National Kidney Foundation Kidney Disease Outcomes Quality Initiative.

<sup>§</sup>Target values recommended by European Best Practice Guideline on Nutrition and Chronic Kidney Disease.

mean ± standard deviation and percent. Differences between the BMI less than 24 kg/m<sup>2</sup> and BMI greater than or equal to 24 kg/m<sup>2</sup> groups were evaluated using the Student's *t*-test or the Wilcoxon rank-sum test for continuous variables and were considered statistically significant at *P* < .05.

## RESULTS

### Patient Characteristics

Demographic, anthropometric, body composition, and laboratory information is summarized in Table 1. The population consisted of 90 RTRs (53.3% men) with a mean age and post-transplant duration of 49.7 ± 12.5 years and 9.1 ± 6.1 years, respectively. The average values of BW, BMI,

waist circumference, visceral fat accumulation, total body fat, and total muscle mass were 63.2 ± 13.3 kg, 24.1 ± 3.9 kg/m<sup>2</sup>, 83.3 ± 9.4 cm, 9.9 ± 8.4 kg, 27.0 ± 7.0%, and 27.8 ± 4.0%, respectively. The average values of serum albumin, creatinine, GFR, and hs-CRP were 4.3 ± .3 g/dL, 1.4 ± .7 g/dL, 55.5 ± 20.8 mL/min/1.73 m<sup>2</sup>, and 5.0 ± 11.9 mg/L, respectively.

### Comparison of Baseline Characteristics in Normal and OBOV Groups

No significant differences were observed regarding age, post-transplant duration, or renal function, whereas BW, BMI, waist circumference, visceral fat accumulation and

total body fat for body composition, low-density lipoprotein cholesterol, total triglyceride for lipid profile, hs-CRP, HOMA-IR, and uric acid were significantly higher in the OBOV group than in the BMI normal group.

#### Daily Intake of Nutrients

Tables 2 and 3 display the daily intake of macronutrients and micronutrients and the proportions of the BMI normal and OBOV groups with intakes according to recommended targets. The average dietary caloric intake was  $1869.1 \pm 383.5$  kcal ( $1775.1 \pm 344.0$  kcal for BMI normal group and  $1959.0 \pm 401.1$  kcal for OBOV group). On the basis of Taiwan Ministry of Health and Welfare DRIs, around two-thirds of RTRs (73.3%) reached the recommended values (77.3% and 69.6% for BMI normal and OBOV groups, respectively). More than half of RTRs (86.7%) ate less than NMAKTR guideline recommendations of .84 and .75 g/kg of protein per day (for males and females, respectively). In general, only 18.9% of RTRs reached the total dietary fat recommended values of the K/DOQI guideline. In further analysis of fat components, around one-third of RTRs exceeded the intake of saturated fatty acid and polyunsaturated fatty acid (30% and 28.9%) compared to current NMAKTR recommendations (8% and 10%). Only 1.1% of RTRs consumed sufficient daily fiber. Less than half of RTRs consumed adequate calcium and magnesium under NMAKTR recommendations or adequate phosphorus, iron, and zinc under EBPG recommendations. With regard to vitamin intake, only consumption of vitamins E and B<sub>12</sub> met current EBPG recommendations in more than half of RTRs, indicating that vitamin intake was inadequate to reach EBPG or DRI recommendations in a majority of subjects.

#### Comparison of Nutrient Intake Between BMI Normal and OBOV Groups

Total caloric and protein intakes were significantly higher in the OBOV group than in the BMI normal group. In contrast, calorie-adjusted BW and protein-adjusted BW were significantly lower in the OBOV group ( $27.6 \pm 6.0$  kcal/kg;  $1.0 \pm .3$  g/kg) than in the BMI normal group ( $33.3 \pm 7.3$  kcal/kg;  $1.2 \pm .3$  g/kg). Other nutrients did not show a significant difference between the 2 groups.

#### DISCUSSION

We investigated whether RTRs at our center were compliant with dietary recommendations. The main findings of this study demonstrated that the OBOV group was significantly different from the BMI normal group in terms of general characteristics (Table 1) and intake of some nutrients (Table 2). The majority of RTRs in the BMI normal and OBOV groups had poor compliance with dietary recommendations (Table 3).

Moderate caloric intake without cutoff was suggested in the NMAKTR recommendations because improper caloric intake may lead to obesity or malnutrition. Therefore, it was

suggested that caloric intake be determined on an individual basis. Lower protein intake was suggested in NMAKTR recommendations for stable RTRs rather than for the healthy general population. In agreement with Marcén et al, in light of the restoration of renal function, stable RTRs were classified by chronic kidney disease (CKD) stage, which is based on the estimated GFR elaborated by the K/DOQI [17]. However, most RTRs (86.7%) in our study failed to meet the NMAKTR guidelines, a finding that seems to agree with a previous study in Japan [18,19]. It has been suggested that low protein intake may prevent renal deterioration in patients with CKD because excess protein intake may increase glomerular pressure and hyperfiltration [20]. Moreover, low-calorie and protein-adjusted BW in the OBOV group might be due to greater BW in the OBOV group.

A high proportion (81%) of RTRs consumed an excessive amount of total dietary fat, consistent with a previous study [21]. Further analysis of the distribution of dietary fats demonstrated that RTRs consumed excessive saturated fatty acid (SFA). Ruiz-Núñez et al indicated that SFA may contribute to systemic low-grade inflammation, changes in lipoprotein metabolism, and ultimately cardiovascular disease (CVD) risk, and may be attributed to unhealthy eating patterns [22]. In addition, dietary fats may be the main source of energy because of dietary restriction during CKD or dialysis [22-24]. Dietary fiber may also provide a beneficial anti-inflammatory effect in CVD protection and metabolic syndrome in both RTRs and healthy individuals [25,26]. In this study, only 1 participant achieved the DRI for fiber under NMAKTR guidelines, implying that eating patterns need to be further improved to decrease the metabolic risk factors in these stable RTRs.

Low intake of various vitamins was observed in this study, except vitamin E, owing to a high proportion of subjects being used to dining out and to increased cooking oil use, which are related to high intake of vitamin E and total dietary fat in Taiwan. Otherwise, some vitamins, such as folic acid or vitamin B<sub>6</sub>, were insufficient, which has been associated with CVD risk factors via hyperhomocysteinemia [27]. Patients with end-stage renal disease are normally considered to be at risk for deficiencies of vitamins and trace element intake, which may be attributed to dietary restrictions [28,29].

Inadequate consumption of minerals encompassed calcium, phosphorus, magnesium, iron, and zinc, particularly calcium and magnesium, consistent with a Japanese study [19]. Calcium and magnesium abnormalities were interactively correlated with some metabolic biomarkers (such as fibroblast growth factor 23, parathyroid hormone, and vitamin D) and were known to increase the risk of CVD [30] and bone disease in RTRs. It is reported that hypercalcemia and hypomagnesemia may contribute to vascular calcification and bone mineralization [31,32]. However, most RTRs in this study consumed calcium and magnesium at less than target values derived from current recommendations, indicating that individual counseling regarding medical nutrition therapy is warranted.

A limitation of this study is that it was a cross-sectional study with a relatively small sample drawn from a single center. Nevertheless, whether dietary nutrient intake meets current guideline recommendations, especially in Taiwan, is rarely reported. Dietary records may have been hindered by patients' dietary underestimation, even though the patients were counseled in an appointment with a trained dietitian. Further prospective studies concerning dietary nutrient intake and the outcomes of RTRs are needed.

## CONCLUSIONS

In both the BMI normal and OBOV groups, most RTRs did not reach current dietary recommendations and their dietary compliance was poor. Excessive dietary fat and protein intake and inadequate intake of fiber, vitamins, and minerals were observed.

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