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ORIGINAL RESEARCH

Food Literacy Is Associated With Adherence to a Mediterranean-Style Diet in Kidney Transplant Recipients

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Objectives: Adherence to a Mediterranean-style diet is associated with improved health outcomes in kidney transplant recipients (KTR). However, poor dietary habits, including excessive sodium intake, are common in KTR, indicating difficulties with incorporating a healthy diet into daily life. Food literacy is identified as potential facilitator of a healthy diet, but the precise relationship between food literacy and dietary intake in KTR has not been investigated. This study examined food literacy levels in KTR and its association with adherence to a Mediterranean-style diet and sodium intake.

Methods: This cross-sectional study is part of the TransplantLines Cohort and Biobank Study. Food literacy was measured with the Self-Perceived Food Literacy (SPFL) questionnaire. Dietary intake assessment with food frequency questionnaires was used to calculate the Mediterranean Diet Score. Sodium intake was based on the 24-hour urinary sodium excretion rate. Associations of SPFL with Mediterranean Diet Score and sodium intake were assessed with univariable and multivariable linear regression analyses.

Results: In total, 148 KTR (age 56 [48-66]; 56% male) completed the SPFL questionnaire with a mean SPFL score of 3.63 ± 0.44. Higher SPFL was associated with a higher Mediterranean Diet Score in KTR (β = 1.51, 95% confidence interval 0.88-2.12, $P \leq .001$). Although KTR with higher food literacy tended to have a lower sodium intake than those with lower food literacy (P = .08), the association of food literacy with sodium intake was not significant in a multivariable regression analysis (β = 0.52 per 10 mmol/24-hour increment, 95% confidence interval −1.79 to 2.83, P = .66).

Conclusions: Higher levels of food literacy are associated with better adherence to a Mediterranean-style diet in KTR. No association between food literacy and sodium intake was found. Further studies are needed to determine if interventions on improving food literacy contribute to a healthier diet and better long-term outcomes in KTR.

Introduction

KIDNEY TRANSPLANTATION IS the treatment of choice for patients with end-stage kidney disease, with a better quality of life and life expectancy compared with those receiving dialysis treatment.[1,2] However, the life expectancy is still considerably lower compared with the general population, which is mainly due to high cardiovascular morbidity and mortality.[1,3,4] Kidney transplant recipients (KTR) often have an unfavorable cardiovascular risk profile, which is characterized by post-transplantation weight gain, obesity, metabolic syndrome, post-transplantation diabetes mellitus (PTDM), and hypertension.[5-10]

In line with the general and other high-risk populations, a healthy diet, characterized by variety of wholegrain products, fruit and vegetables, nuts, legumes, lean meats and fish, as well as the avoidance of excessive sodium intake, is associated with lower cardiovascular risks in KTR.[11-16] Previous studies showed that better adherence to a Mediterranean-style diet is associated with a lower risk of PTDM and all-cause mortality as well as better kidney function outcomes in KTR.[16,17] Furthermore, small

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Box 1 Routine nutritional management in our center

In the routine nutritional management in our center, KTR receives at least 1 inpatient visit by a renal dietitian at the time of transplantation. This visit encompasses dietary advices regarding optimal nutritional intake to support postoperative recovery and the avoidance of high-risk infectious food products and specific foods that interfere with medication. At discharge, patients receive a standard brochure with both general and specific dietary advices regarding a healthy diet after transplantation. Patients are invited for an outpatient visit 3 months after transplantation and receive individualized advices based on their needs and medical history. If indicated, the nephrologist refers for additional counseling by a renal dietitian, e.g., in case of excessive weight gain, obesity, or post-transplantation diabetes. The renal dietitians are trained in motivational interviewing to support the change in dietary behavior. Health literacy screening and providing support for skill development is not yet part of current practice. As recommendations for nutritional guidance are currently not incorporated in the guidelines for KTR, the nutritional counseling is according to the standards of our center.

randomized controlled trials (RCTs) showed that a dietary sodium restriction is an effective measure for lowering blood pressure in KTR.[18-20] These findings indicate the importance of a healthy diet after kidney transplantation.

Unfortunately, despite nutritional counseling by a renal dietitian in our center (outlined in Box 1), poor dietary habits remain in the majority of KTR. For example, excessive sodium intake is seen in up to 95% of KTR and the mean vegetable consumption is even lower than it already is in the general population[10,14] and not in line with the Dutch Dietary Guidelines.[21] These observations indicate the difficulty with incorporating healthy dietary habits into daily life, which requires behavioral change as well as the skills to translate dietary advices into practice.

Among various individual and environmental factors that influence dietary habits in a positive or negative way,[22-24] we recently identified food knowledge and food-related skills as facilitator of dietary adherence in a focus group study in KTR.[24] For example, the food-related skills were related to the selection of food products (e.g., reading and understanding food labels) and preparation of meals (e.g., modifying recipes). These findings relate to the concept food literacy, defined as a collection of interrelated knowledge, skills, and behaviors required to plan, manage, select, prepare, and eat food healthfully.[25,26] In the general population, people with lower food literacy levels have difficulties to interpret food labels, select the right products, balance food intake with needs, and prepare healthy meals.[25,26] This corresponds with the 4 domains of food literacy: planning and management, selection, preparation, and eating. Food literacy is derived from the broader concept health literacy, which is known to be associated with graft function,[27] transplant waitlist mortality,[28] and—in mild to moderate chronic kidney disease (CKD)—unhealthy lifestyle behaviors.[29] For food literacy, the association with a healthy diet and health outcomes has not been explored in KTR.

A recent web-based self-management intervention for dietary sodium restriction in kidney patients including KTR as well as other CKD patients, aiming to support a behavioral change as well as to improve the knowledge and required skills to reduce sodium intake, was effective in lowering of sodium intake and blood pressure.[30] This suggests that enhancing food knowledge and skills may be a valuable counseling strategy to support KTR in adopting a healthy diet. However, to our knowledge, the relationship between individual food literacy levels and dietary intake has not been studied before in KTR.

In this study, therefore, we aim to investigate food literacy levels in KTR and examine its association with adherence to a Mediterranean-style diet and with sodium intake. Insight in the relationship between food literacy and food consumption may provide useful information for improvement in dietary counseling and future dietary intervention studies.

Methods

Study Design and Population

This study is part of the TransplantLines Biobank and Cohort study of the University Medical Center Groningen (UMCG) in the Netherlands.[31] In brief, since June 2015 both new transplant candidates as well as transplant recipients with a functioning graft, who visited the outpatient clinic of the UMCG, are invited to participate in this ongoing study. The study protocol was approved by the Institutional Review Board the UMCG (METc 2014/077) and adhered to the principles of the Declaration of Helsinki. Before inclusion, written informed consent was obtained from all eligible transplant recipients. All transplant recipients who were included at the time of transplantation were asked to fill out a comprehensive questionnaire at the 1-year visit post-transplantation, which included a Food Frequency Questionnaire (FFQ). Transplant recipients who were included at more than 1-year post-transplantation completed the same questionnaire as part of the study visit. During these study visits sociodemographic data as well as clinical and laboratory parameters were collected.

For this study, 190 KTR, which were 1 year or later post-transplantation and completed an FFQ[32] in the past 12 months, were invited to complete the Self-Perceived Food Literacy (SPFL) questionnaire[26] and All Aspects of Health Literacy Scale (AAHLS).[33] This additional data collection took place between June 2019 and January 2020. Of all 190 KTR, both respondents and non-respondents to the additional SPFL and AAHLS questionnaires, we used the sociodemographic, clinical, laboratory, and FFQ data of the most recent study visit within the past 12 months.

Data Collection and Measurements

Assessment of Food and Health Literacy

Food literacy levels were examined by the SPFL questionnaire that consists of 29 items with a 5-point Likert scale for the response options (1 = "not at all/never" to 5 = "yes/always").[26] Questions were related to 8 subthemes: "food preparation skills," "resilience and resistance," "healthy snack styles," "social and conscious eating," "examining food labels," "healthy budgeting," and "healthy food stockpiling." The questionnaire was evaluated by a renal dietitian, nephrologist, and a panel of 7 KTR to assess the comprehensibility and the applicability in the kidney transplant setting. Based on this evaluation few adaptations were made in the examples and explanation of certain questions (see Supplementary Document S1). For calculating the SPFL score, the negative items were reversed, indicating that a higher score reflects a higher food literacy level. The mean SPFL score was the mean of the individual scores of the 29 items (score range 1-5). Lower food literacy was defined as an SPFL score at the lowest tertile of mean SPFL score. Based on the 8 SPFL subthemes, mean scores were also calculated for the 4 domains of food literacy: "planning and management," "selection," "preparation," and "eating" (see Supplementary Document S1).

Health literacy was measured with 10 items of the AAHLS questionnaire, which enables to discriminate among functional, communicative, and critical health literacy.[33] Each item consists of a 3-point Likert scales for the response options (1 = "often," 2 = "sometimes," and 3 = "seldom"). For the 3 domains of health literacy (functional, communicative, and critical) a mean score (range 1-3) was calculated. Three questions regarding empowerment at community and social engagement level were considered irrelevant in this context.

The SPFL and AAHLS questionnaires were sent digitally or by post if this was preferred by the participants. After 1 month, a reminder was sent by e-mail or participants were contacted by telephone.

Assessment of Dietary Intake and Calculation of Mediterranean Diet Score

A validated, semi-quantitative 177-item FFQ was used to estimate the dietary intake of the participants.[32] This FFQ was developed by Wageningen University and Research[34] and has been updated several times.[35] The questionnaire was self-administered and completed at home before a scheduled study visit. A trained researcher checked the FFQs on completeness, and verified inconsistent answers with participants if needed. This FFQ is validated in KTR[36] and used in previous studies in KTR for calculating the Mediterranean Diet Score.[16,17] The FFQ inquired about the consumption of the food items of the past month and considers seasonal variations. For each item, the frequency was recorded in times per day, week, or month. Then, the number of servings was recorded and expressed in natural units or household measures (e.g., cup or spoon). Finally, of each food product group the consumption was calculated in grams per day (g/d).

For calculating the Mediterranean Diet Score the method of Trichopoulou et al. was used.[37] Food items of the FFQ were divided into 9 food groups (ratio monounsaturated: saturated fatty acids, legumes/nuts/soy products, cereals, fruit, vegetables, meat, dairy, fish, and alcohol; Supplementary Document S2). Subsequently, the sex-specific median intake of each food category was calculated and KTR received either 1 or 0 points per food category based on the median intake. For 6 food categories (high ratio of monounsaturated to saturated fatty acids, legumes and nuts, cereals, vegetables, fruit, and fish) KTR with a consumption above the sex-specific median intake received 1 point. For the food groups "meat" and "dairy" 1 point was assigned in case of a consumption below the sex-specific median intake. Alcohol consumption was scored as 1 in case of an intake between 10 and 50 g/day for men and between 5 and 25 g/day for women. The Mediterranean Diet Score was obtained by adding the scores of all 9 food categories, resulting in a total score between 0 (lowest adherence) and 9 (highest adherence). For the daily sodium intake the 24-hour urinary sodium excretion was used, since urinary sodium excretion largely reflects sodium intake in steady state and the FFQ tends to underestimate sodium intake due to difficulties in quantifying sodium content of processed and home cooked meals.[38]

Other Data Collection

Sociodemographic data were collected by use of a questionnaire at the study visit. The measurement of the clinical parameters (e.g., weight, height, blood pressure, and waist circumference) has been described in detail previously. For calculation of the body mass index weight (in kilograms) was divided by height (in squared meter). Fasted blood samples were collected prior to the study visit for measurement of laboratory parameters. The serum creatinine-based Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) algorithm was used for calculation of the estimated glomerular filtration rate (eGFR).[39] Diabetes was diagnosed when one or more of the following criteria were present: (1) symptoms of diabetes plus a non-fasting plasma glucose concentration ≥11.1 mmol/L

(200 mg/dL), (2) fasting plasma glucose ≥7.0 mmol/L (126 mg/dL), (3) plasma HbA1c ≥ 6.5% (48 mmol/mol), or (4) use of antidiabetic medication.[40] Information on the transplantation and dialysis history as well as the primary kidney disease was obtained from the UMCG Kidney Transplant Database. Information on the necessity for nutrient restrictions was obtained from the electronic patient records, because these restrictions can influence the dietary pattern (e.g., restriction of fruit and vegetable consumption for restriction of potassium intake) irrespective of the food literacy level.

Statistical Analysis

Patient characteristics were presented as mean ± standard deviation (SD) for normally distributed data, median (interquartile range [IQR]) for non-normally distributed data, and number (percentages) for nominal data. The study population was then divided into 2 groups—the lowest tertile versus the highest 2 tertiles according to the total SPFL score—to show associations between SPFL and the baseline characteristics. Differences in patient characteristics between KTR with lower food literacy (lowest tertile, total SPFL score <3.41)or higher food literacy (highest 2 tertiles, total SPFL score ≥ 3.41) were evaluated with independent *t*-test for normally distributed continuous variables, the Mann-Whitney *U*-test for non-normally distributed variables, and either the chi-squared test or Fisher's exact test for nominal variables. For examining differences in main baseline characteristics between respondents and non-respondents of the SPFL and AAHLS questionnaire, similar statistical tests were used for normally distributed, skewedly distributed, and categorical variables. A *P*-value <.05 (2-tailed) was considered as statistically significant.

Univariable and multivariable linear regression analysis was performed to assess the association of food literacy levels (range 1-5) with Mediterranean Diet Score and 24-hour sodium excretion rate (mmol/24 hours). In the multivariable regression analysis, we adjusted for the following variables in separate models: age and sex (model 1); model 1 plus body mass index, waist circumference, diabetes, cholesterol, and systolic blood pressure (model 2); model 1 plus eGFR, pre-emptive transplantation, living kidney donor, and proteinuria (model 3); model 1 plus employment status and level of education (model 4); model 1 plus smoking status and alcohol use (model 5); and a full model with all variables of model 1-5 (model 6). In a sensitivity analysis, it was assessed if exclusion of KTR who are not responsible for meal preparation themselves influenced the results. Data were analyzed using SPSS software, version 23.0 (IBM Corp., Armonk, NY).

Results

Baseline Characteristics

The questionnaire was completed by 148 of 190 KTR (78%). Comparing the main baseline characteristics of non-respondents with respondents of the SPFL and AAHLS questionnaire, non-respondents were significantly younger compared to the respondents (median age of 48 [IQR 36-56] vs. 56 [IQR 48-66] years, *P* = .003). No significant differences were found in the other main baseline characteristics (Supplementary Document S3).

Of the 148 KTR, the mean age was 56 [48-66] years, 66% was male, the mean eGFR was 53.7 ± 19.0 mL/min/1.73 m^2, and mean plasma potassium level was 4.02 ± 0.37 mmol/L. End-stage kidney failure, which required dietary restrictions, was present in one KTR. The mean fruit and vegetable consumption was 129 g/day and 127 g/day respectively. The mean SPFL score was 3.63 ± 0.44. The majority of KTR reported maximum scores at the functional and communicative domain of the AAHLS, the mean critical health literacy score was 1.79 ± 0.51. All baseline characteristics of the total group and across categories of food literacy levels are shown in Table 1. KTR with higher food literacy levels (SPFL score ≥ 3.41) were more often female, had a higher age, had higher level of education, and were less often an active smoker compared with those with a lower food literacy level. No significant differences were found in the transplant-related and cardiometabolic parameters, except for the time after transplantation; KTR with lower food literacy levels received the kidney transplantation longer time ago. KTR with higher food literacy levels had a significantly higher Mediterranean Diet Score compared with those with lower food literacy levels, which is also reflected by a higher fruit, vegetable, and fish consumption. KTR with a higher food literacy level tended to limit their salt consumption <6 g/d more often than KTR with lower food literacy levels (*P* = .08). However, in both groups the majority of KTR exceeded the advised salt consumption of 6 g/day. Finally, KTR with lower food literacy levels were less often involved in meal preparation.

Food Literacy and Adherence to Mediterranean-Style Diet

In univariable linear regression analysis, higher mean SPFL scores were associated with a higher Mediterranean Diet Score, reflecting better adherence to a Mediterranean-style diet (β = 1.51, 95% confidence interval 0.88-2.12, *P* ≤ .001) (Table 2). These associations remained significant after correction for age and sex (model 1), cardiometabolic parameters (model 2), transplant-related parameters (model 3), employment status and level of education (model 4), smoking status and alcohol use (model 5), as well as a full model (model 6) in the

Table 1. Baseline Characteristics of the Overall KTR Population and According to 2 Groups Based on the Mean SPFL Score

	Food Literacy			
Characteristics	Total Population	Lower FL (SPFL Score < 3.41)	Higher FL (SPFL Score ≥ 3.41)	*P* Value
Number of subjects, n (%)	148 (100)	44 (33)	101 (67)	
Sociodemographic parameters				
Sex: male, n (%)	83 (56)	33 (72)	50 (49)	.01
Age (y)	56 [48-66]	51 [45-62]	59 [49-66]	.04
Education, n (%)				.08
Low	49 (33)	20 (44)	29 (29)	
Medium	55 (38)	17 (38)	38 (37)	
High	42 (29)	8 (18)	34 (34)	
Employment status				.51
Paid employment	61 (43)	21 (48)	40 (40)	
Medically unfit for work	29 (20)	10 (23)	19 (19)	
Unemployed	12 (8)	4 (9)	8 (8)	
Retired	42 (29)	9 (20)	33 (33)	
Health literacy (AAHLS)				
Functional	3.0 [2.67-3.0]	3.0 [2.67-3.0]	3.0 [2.67-3.0]	.79
Interactive	3.0 [2.67-3.0]	3.0 [2.67-3.0]	3.0 [2.67-3.0]	.38
Critical	1.79 ± 0.51	1.60 ± 0.51	1.88 ± 0.49	<.001
Transplantation and disease history				
Primary kidney disease, n (%)				.91
Glomerulonephritis	40 (27)	15 (33)	25 (24)	
Interstitial nephritis	11 (7)	3 (6)	8 (8)	
Cystic kidney disease and other congenital/hereditary kidney disease	31 (21)	8 (17)	23 (22)	
Renal vascular disease including diabetes mellitus	23 (16)	6 (13)	17 (17)	
Other multisystem diseases	9 (6)	3 (7)	6 (6)	
Other/unknown	34 (23)	11 (24)	23 (23)	
Time after transplantation (y)	1.04 [0.99-9.08]	3.4 [1.0-12.1]	1.0 [0.9-7.3]	.02
Pre-emptive, n (%)	64 (44)	18 (40)	46 (46)	.53
Living donor, n (%)	89 (62)	24 (56)	65 (65)	.30
Body composition				
Weight (kg)	82.3 ± 16.1	85.3 ± 15.8	81.0 ± 16.1	.14
BMI (kg/m^2)	27.4 ± 4.6	27.4 ± 4.7	27.4 ± 4.7	.98
Waist circumference (cm), male	103 ± 13	104 ± 14	103 ± 13	.77
Waist circumference (cm), female	94 ± 13	95 ± 16	94 ± 12	.68
Kidney function parameters				
eGFR (mL/min/1.73 m^2)	53.7 ± 19.0	51.2 ± 20.8	54.8 ± 18.2	.31
Plasma potassium (mmol/L)	4.02 ± 0.37	4.10 ± 0.42	3.99 ± 0.35	.10
Proteinuria, n (%)	15 (10)	7 (18)	8 (9)	.11
Cardiometabolic parameters				
SBP (mm Hg)	132 ± 14	129 ± 10	133 ± 16	.12
DBP (mm Hg)	78 ± 10	78 ± 11	78 ± 10	.90
Use of antihypertensive drugs, n (%)	110 (74)	38 (83)	72 (71)	.12
Total cholesterol (mmol/L)	4.43 ± 0.86	4.3 ± 0.9	4.5 ± 0.9	.13
LDL-cholesterol (mmol/L)	2.67 ± 0.76	2.5 ± 0.8	2.7 ± 0.7	.14
Diabetes, n (%)	32 (22)	6 (13)	26 (26)	.09
Immunosuppressive drugs				
Tacrolimus, n (%)	111 (77)	31 (71)	80 (79)	.25
Cyclosporine, n (%)	15 (10)	6 (14)	9 (9)	.39
Mycophenolic acid, n (%)	112 (77)	31 (71)	81 (80)	.20
Azathioprine, n (%)	17 (12)	4 (9)	13 (13)	.52
Prednisolone, n (%)	139 (96)	41 (93)	98 (97)	.29
Nutrition intake and biomarkers				
Salt consumption (g/d)	8.6 ± 3.5	9.1 ± 2.9	8.4 ± 3.7	.34
Salt consumption < 6 g/d, n (%)	33 (25)	6 (15)	27 (29)	.08
Mediterranean diet score	4.3 ± 1.7	3.4 ± 1.4	4.6 ± 1.7	<.001
Vegetable consumption (g/d)	127 [74-192]	93 [61-152]	145 [94-196]	.09
Fruit consumption (g/d)	129 [79-224]	88 [29-121]	193 [96-241]	<.001
Fish consumption (times per week)				.002
Never	26 (19)	10 (24)	16 (16)	

(*Continued*)

Table 1. Baseline Characteristics of the Overall KTR Population and According to 2 Groups Based on the Mean SPFL Score (*Continued*)

Characteristics	Food Literacy			
	Total Population	Lower FL (SPFL Score < 3.41)	Higher FL (SPFL Score ≥ 3.41)	*P* Value
<1	60 (43)	25 (60)	35 (36)	
≥1	54 (38)	7 (16)	47 (48)	
Other lifestyle parameters				
Smoking status				.04
Yes	10 (7)	6 (13)	4 (4)	
No	136 (92)	40 (87)	97 (96)	
Alcohol use				.56
Yes	85 (57)	24 (56)	61 (61)	
No	58 (40)	19 (44)	39 (39)	
Involvement in meal preparation				
Grocery shopping, n (%)	103 (70)	24 (52)	79 (78)	.002
Cooking of main meal, n (%)	94 (64)	20 (44)	74 (73)	.001

AAHLS, All Aspects of Health Literacy Scale; BMI, body mass index; DBP, diastolic blood pressure; eGFR, estimated glomerular filtration rate; FL, food literacy; g/d: grams per day; KTR, kidney transplant recipients; LDL, low-density lipoprotein; SBP, systolic blood pressure; SPFL score, Self-Perceived Food Literacy score.

Table 2. Association of Mean SPFL Score With Mediterranean Diet Score and Sodium Intake in KTR

Models	Mediterranean Diet Score		Sodium Intake*	
	β (95% CI)	*P*-Value	β (95% CI)	*P*-Value
Crude	1.51 (0.88-2.12)	<.001	0.52 (−1.79 to 2.83)	.66
Model 1	1.45 (0.72-2.24)	<.001	1.80 (−0.44 to 4.04)	.11
Model 2	1.62 (0.93-2.32)	<.001	1.67 (−0.79 to 4.13)	.18
Model 3	1.54 (0.83-2.25)	<.001	2.03 (−0.30 to 4.37)	.09
Model 4	1.49 (0.78-2.19)	<.001	2.02 (−0.38 to 4.43)	.10
Model 5	1.51 (0.88-2.16)	<.001	1.86 (−0.44 to 4.15)	.11
Model 6	1.44 (0.65-2.23)	<.001	2.22 (−0.47 to 4.92)	.11

BMI, body mass index; CI, confidence interval; eGFR, estimated glomerular filtration rate; KTR, kidney transplant recipients; SPFL, Self-Perceived Food Literacy.

Model 1: adjusted for age and sex; Model 2: adjusted for model 1 variables plus BMI, waist circumference, diabetes, total cholesterol, and systolic blood pressure; Model 3: adjusted for model 1 variables plus eGFR, proteinuria, time after transplantation, pre-emptive transplantation, and living kidney donor; Model 4: adjusted for model 1 variables plus employment status and level of education; Model 5: adjusted for model 1 variables plus smoking status and alcohol use; and Model 6: full model, adjusted for all variables of model 1-5.

*Based on the 24-h urinary sodium excretion rate (in mmol); β and 95% CI per 10 mmol increment in 24-h urinary sodium excretion rate.

multivariable linear regression analyses. A subsequent sensitivity analysis was performed in KTR that were involved in meal preparation (Supplementary Document S4). The association of SPFL with Mediterranean Diet Score remained significant in univariable and multivariable linear regression analyses.

Food Literacy and Sodium Intake

For sodium intake no significant association was found with the SPFL score in both univariable and multivariable linear regression analyses (β = 0.52 per 10 mmol/24-hour increment, 95% confidence interval −1.79 to 2.83, P = .66) (Table 2). In the sensitivity analysis in KTR involved in meal preparation, similar results were found (Supplementary Document S4).

Discussion

In this study, we examined the individual food literacy levels of KTR and the association of food literacy with the Mediterranean Diet Score and sodium intake. We demonstrated that in KTR higher food literacy levels were independently associated with a better adherence to a Mediterranean-style diet—consisting of favorable monounsaturated to saturated fatty acids ratio, a higher fruit, vegetable, legumes and fish consumption, a lower dairy and meat consumption, and moderate alcohol consumption. In contrast with these findings, no significant association was found between food literacy and sodium intake.

To our knowledge, we are the first to investigate a potential association of food literacy with adherence to the Mediterranean-style diet in KTR. It is important to investigate this because recent studies showed that better adherence to a Mediterranean-style is associated with a lower risk of developing PTDM and kidney function decline as well as a lower mortality risk after kidney transplantation.[16,17] Our findings are in line with results from the general population and cancer patients, where a relationship between food literacy and healthy diet was also found.[26,41] Since KTR with higher food literacy levels were also more involved in grocery shopping and cooking, we hypothesize that KTR, but also other high risk populations, might benefit from developing skills to select the right products and prepare healthy meals, to improve dietary intake.

We found no significant association of food literacy with sodium intake, which is in line with a recent study in 141 healthy Swiss employees.[42] A subsequent educational and environmental workplace intervention in this population resulted in a modest improvement in sodium intake,[43] indicating the general difficulty of modifying sodium intake. Although KTR are highly aware of the importance of limiting their sodium intake,[24] the majority of KTR exceeds the recommendation of daily salt consumption of 6 g/d.[10] This may be attributed to other individual or environmental barriers, such as food or taste preferences, the high content of hidden salt in processed and catered food products, or the lack of social support in lowering sodium intake.[24,44,45]

Our findings emphasize the importance of seeking alternative counseling strategies that focus more on skill development and behavioral change, instead of solely providing dietary advice. The importance of educating both nutritional knowledge and skills is acknowledged in several RCTs in CKD patients.[46-48] In these studies, intensive dietary counseling, with additional (community) cooking classes, hands-on educational sessions, and recipe booklets, was more effective than standard care with regular dietary counseling for reduction of either protein intake or sodium intake and blood pressure control. In addition, interventions that incorporate a behavioral approach, combined with practical education sessions, have also proven to be effective in reducing salt consumption in CKD patients.[30,49] Participants of this study highly valued the practical advices of group educational sessions and stressed the importance of partner or family involvement.[30] For improving both the overall diet quality and sodium intake in KTR, a combined intervention focused on food literacy, behavioral change, and involvement of partner or family members may be an effective approach. Disease-specific barriers, which are, e.g., related to previous dietary restrictions, should be considered in case of poor fruit or vegetable consumption.[24] Beyond educational interventions, food industry and retailers may integrate supportive strategies that can help KTR patients in selecting low sodium products at point of purchases, e.g., by-product reformulation (lowering sodium content)[50] or a clear indication of the salt content of products.[51] In addition, tools like a salt reduction smartphone app can enable shoppers to select lower salt alternatives while shopping.[52]

Sociodemographic and lifestyle factors that are associated with food literacy included age, gender, level of education, and smoking. This is in line with research on health literacy in CKD that also found these associations.[53] Additionally, it was noted that KTR with lower food literacy levels received the kidney transplantation longer time ago. This could be due to a cohort effect or to more exposure to a renal dietitian in the first year after transplantation compared with those who received the transplantation longer time ago. Despite a generally long history of CKD, along with a longstanding exposure to dietary support, the absolute food literacy levels of KTR (3.63, SD 0.44) are lower compared with a previous study in healthy individuals and dietitians, where a mean SPFL score was found of 3.83 (SD = 0.41) and 3.99 (SD = 0.30), respectively.[26] Although this difference can be explained by the high proportion of women, higher level of education, and possibly greater affinity with healthy eating in the population of the prior study,[26] this finding underlines that in the dietary counseling more attention could be paid to skill development of patients.

Our results also emphasize the importance of incorporating the relatively new concept of food literacy into future dietary intervention studies in KTR. Studies that specifically examine food literacy or incorporate the concept in dietary (educational) interventions for patients are currently scarce.[54-56] However, several barriers are related to the access, understanding, and use of nutritional information were found in patients with chronic respiratory disease.[56] Furthermore, a pilot RCT among breast cancer survivors examined the feasibility of a nutritional literacy intervention that consists of 6 educational sessions[55] and the use of a specific nutrition literacy assessment tool.[54] No differences in nutrition literacy were detected post-intervention, which may be due to high nutrition literacy scores at baseline. In contrast to limited studies in patients, various food literacy interventions were performed in public health setting. A recent example consisted of a 4-week nutrition and cooking program for Australian adults with low-to-middle income level, resulting in higher food literacy levels and a modest increase in fruit and vegetable consumption.[57]

This study has several limitations. The SPFL questionnaire included subjective, self-reported questions to determine the level of food literacy. In a recent review of food literacy measurements by Amouzandeh et al.[58] the use of task-based, objective items was regarded more reliable, as self-reported skills not always adequately reflect the actual use of these skills (e.g., label reading) in practice. Second, selection bias cannot be ruled out. Most included KTR reported high scores at the 3 domains of health literacy. In other patient populations, less research participation in people with low health literacy has been confirmed.[59] Patients with low health literacy, who require support in completing a questionnaire, may not have responded and are not included in this study. Consequently, our results might have underestimated the actual problem, especially for the domain of reading food labels, which acquires similar skills. However, within our population, significant variation in other characteristics as well as food literacy was found. We, therefore, believe that this selection bias has not impacted our results. Finally, the dietary intake measurement of participants was only available at one time point. Therefore, we could not correct for changes in dietary intake over time.

The following implications can be derived from these study findings. As we demonstrated the association of higher food literacy with better adherence to a Mediterranean-style diet, enhancing food literacy levels may be a potential target in future dietary intervention studies in KTR. Second, the SPFL questionnaire may be a useful tool for measuring food literacy. For example, in practice, insight in the different subdomains of food literacy may guide individual counseling by a renal dietitian.

In conclusion, higher levels of food literacy, measured with the SPFL questionnaire, are associated with better adherence to a Mediterranean-style diet in KTR. The association between food literacy and sodium intake is less consistent. Further studies are needed to determine if interventions focused on improving food literacy may contribute to a healthier diet and better long-term outcomes in KTR.

Practical Implications

In this study, we examined individual food literacy levels in kidney transplant recipients and showed that higher food literacy levels are associated with better adherence to a Mediterranean-style diet. Enhancing food literacy levels may be a potential target in future dietary intervention studies aiming to improve dietary intake and health outcomes of KTR.

Credit Authorship Contribution Statement

Karin Boslooper-Meulenbelt: Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft. **Marco D. Boonstra:** Methodology, Resources, Writing - original draft. **Iris M.Y. van Vliet:** Writing - review & editing. **Antonio W. Gomes-Neto:** Resources, Writing - review & editing. **Maryse C.J. Osté:** Methodology, Writing - review & editing. **Maartje P. Poelman:** Methodology, Resources, Writing - review & editing. **Stephan J.L. Bakker:** Resources, Formal analysis, Writing - review & editing. **Andrea F. de Winter:** Supervision, Writing - review & editing. **Gerjan J. Navis:** Supervision, Writing - review & editing.

Supplementary Data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1053/j.jrn.2020.12.010.

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References

1. Kramer A, Pippias M, Noordzij M, et al. The European Renal Association – European Dialysis and Transplant Association (ERA-EDTA) registry annual report 2016: a summary. *Clin Kidney J.* 2019;12:702-720.

2. Jofré R, López-Gómez JM, Moreno F, Sanz-Guajardo D, Valderrábano F. Changes in quality of life after renal transplantation. *Am J Kidney Dis.* 1998;32:93-100.

3. Oterdoom LH, De Vries APJ, Van Ree RM, et al. N-terminal pro-B-type natriuretic peptide and mortality in renal transplant recipients versus the general population. *Transplantation*. 2009;87:1562-1570.

4. Jardine AG, Gaston RS, Fellstrom BC, Holdaas H. Prevention of cardiovascular disease in adult recipients of kidney transplants. *Lancet.* 2011;378:1419-1427.

5. Ducloux D, Kazory A, Simula-Faivre D, Chalopin J-M. One-year post-transplant weight gain is a risk factor for graft loss. *Am J Transpl*. 2005;5:2922-2928.

6. Pedrollo EF, Corrêa C, Nicoletto BB, et al. Effects of metabolic syndrome on kidney transplantation outcomes: a systematic review and meta-analysis. *Transpl Int*. 2016;29:1059-1066.

7. Friedman AN, Miskulin DC, Rosenberg IH, Levey AS. Demographics and trends in overweight and obesity in patients at time of kidney transplantation. *Am J Kidney Dis.* 2003;41:480-487.

8. Cashion AK, Hathaway DK, Stanfill A, et al. Pre-transplant predictors of one yr weight gain after kidney transplantation. *Clin Transpl.* 2014;28:1271-1278.

9. Conte C, Secchi A. Post-transplantation diabetes in kidney transplant recipients: an update on management and prevention. *Acta Diabetol.* 2018;55:763-779.

10. van den Berg E, Geleijnse JM, Brink EJ, et al. Sodium intake and blood pressure in renal transplant recipients. *Nephrol Dial Transpl.* 2012;27:3352-3359.

11. Estruch R, Ros E, Salas-Salvadó J, et al. Primary prevention of cardiovascular disease with a Mediterranean diet supplemented with extra-virgin olive oil or nuts. *N Engl J Med*. 2018;378:e34.

12. Esposito K, Maiorino MI, Bellastella G, Chiodini P, Panagiotakos D, Giugliano D. A journey into a Mediterranean diet and type 2 diabetes: a systematic review with meta-analyses. *BMJ Open*. 2015;5:e008222.

13. Nafar M, Noori N, Jalali-Farahani S, et al. Mediterranean diets are associated with a lower incidence of metabolic syndrome one year following renal transplantation. *Kidney Int*. 2009;76:1199-1206.

14. Gomes-Neto AW, Osté MCJ, Sotomayor CG, et al. Fruit and vegetable intake and risk of posttransplantation diabetes in renal transplant recipients. *Diabetes Care.* 2019;42:1645-1652.

15. Sotomayor CG, Gomes-Neto AW, Eisenga MF, et al. Consumption of fruits and vegetables and cardiovascular mortality in renal transplant recipients: a prospective cohort study. *Nephrol Dial Transpl.* 2018;35:357-365.

16. Osté MCJ, Corpeleijn E, Navis GJ, et al. Mediterranean style diet is associated with low risk of new-onset diabetes after renal transplantation. *BMJ Open Diabetes Res Care.* 2017;5:e000283.

17. Gomes-Neto AW, Osté MCJ, Sotomayor CG, et al. Mediterranean style diet and kidney function loss in kidney transplant recipients. *Clin J Am Soc Nephrol.* 2020;15:238-246.

18. Keven K, Yalçin S, Canbakan B, et al. The impact of daily sodium intake on posttransplant hypertension in kidney allograft recipients. *Transpl Proc.* 2006;38:1323-1326.

19. Soypacaci Z, Sengul S, Yıldız EA, et al. Effect of daily sodium intake on post-transplant hypertension in kidney allograft recipients. *Transpl Proc.* 2013;45:940-943.

20. De Vries LV, Dobrowolski LC, Van Den Bosch JJON, et al. Effects of dietary sodium restriction in kidney transplant recipients treated with renin-angiotensin-aldosterone system blockade: a randomized clinical trial. *Am J Kidney Dis.* 2016;67:936-944.

21. Kromhout D, Spaaij CJK, de Goede J, Weggemans RM. The 2015 Dutch food-based dietary guidelines. *Eur J Clin Nutr.* 2016;70:869-878.

22. Gordon EJ, Prohaska TR, Gallant M, Siminoff LA. Self-care strategies and barriers among kidney transplant recipients: a qualitative study. *Chronic Illn*. 2009;5:75-91.

23. Stanfill A, Bloodworth R, Cashion A. Lessons learned: experiences of gaining weight by kidney transplant recipients. *Prog Transpl*. 2012;22:71-78.

24. Boslooper-Meulenbelt K, Patijn O, Battjes-Fries MCE, Haisma H, Pot GK, Navis GJ. Barriers and facilitators of fruit and vegetable consumption in renal transplant recipients, family members and healthcare professionals – a focus group study. *Nutrients.* 2019;11:2427.

25. Vidgen HA, Gallegos D. Defining food literacy and its components. *Appetite*. 2014;76:50-59.

26. Poelman MP, Dijkstra SC, Sponselee H, et al. Towards the measurement of food literacy with respect to healthy eating: the development and validation of the self perceived food literacy scale among an adult sample in The Netherlands. *Int J Behav Nutr Phys Act*. 2018;15:1-12.

27. Gordon EJ, Wolf MS. Health literacy skills of kidney transplant recipients. *Prog Transpl*. 2009;19:25-34.

28. Warsame F, Haugen CE, Ying H, et al. Limited health literacy and adverse outcomes among kidney transplant candidates. *Am J Transpl.* 2019;19:457-465.

29. Schrauben SJ, Hsu JY, Wright Nunes J, et al. Health behaviors in younger and older adults with CKD: results from the CRIC study. *Kidney Int Reports.* 2019;4:80-93.

30. Humalda JK, Klaassen G, de Vries H, et al. A self-management approach for dietary sodium restriction in patients with CKD: a randomized controlled trial. *Am J Kidney Dis.* 2020;75:847-856.

31. Eisenga MF, Gomes-Neto AW, van Londen M, et al. Rationale and design of TransplantLines: a prospective cohort study and biobank of solid organ transplant recipients. *BMJ Open*. 2018;8:e024502.

32. Willet WC, Sampson L, Stampfer MJ, et al. Reproducibility and validity of a semiquantitative food frequency questionnaire. *Am J Epidemiol.* 1985;122:51-65.

33. Chinn D, McCarthy C. All Aspects of Health Literacy Scale (AAHLS): developing a tool to measure functional, communicative and critical health literacy in primary healthcare settings. *Patient Educ Couns.* 2013;90:247-253.

34. Feunekes GI, Van Staveren WA, De Vries JH, Burema J, Hautvast JG. Relative and biomarker-based validity of a food-frequency questionnaire estimating intake of fats and cholesterol. *Am J Clin Nutr.* 1993;58:489-496.

35. van den Berg E, Engberink MF, Brink EJ, et al. Dietary acid load and metabolic acidosis in renal transplant recipients. *Clin J Am Soc Nephrol.* 2012;7:1811-1818.

36. Van Den Berg E, Engberink MF, Brink EJ, et al. Dietary protein, blood pressure and renal function in renal transplant recipients. *Br J Nutr.* 2013;109:1463-1470.

37. Trichopoulou A, Katsouyanni K, Stuver S, et al. Consumption of olive oil and specific food groups in relation to breast cancer risk in Greece. *JNCI J Natl Cancer Inst*. 1995;87:110-116.

38. McLean RM. Measuring population sodium intake: a review of methods. *Nutrients.* 2014;6:4651-4662.

39. Ix JH, Wassel CL, Stevens LA, et al. Equations to estimate creatinine excretion rate: the CKD epidemiology collaboration. *Clin J Am Soc Nephrol.* 2011;6:184-191.

40. Sharif A, Hecking M, de Vries APJ, et al. Proceedings from an international consensus meeting on posttransplantation diabetes mellitus: recommendations and future directions. *Am J Transpl.* 2014;14:1992-2000.

41. Taylor MK, Sullivan DK, Ellerbeck EF, Gajewski BJ, Gibbs HD. Nutrition literacy predicts adherence to healthy/unhealthy diet patterns in adults with a nutrition-related chronic condition. *Public Health Nutr.* 2019;22:2157-2169.

42. Luta X, Hayoz S, Gréa Krause C, et al. The relationship of health/food literacy and salt awareness to daily sodium and potassium intake among a workplace population in Switzerland. *Nutr Metab Cardiovasc Dis.* 2018;28:270-277.

43. Beer-Borst S, Hayoz S, Eisenblätter J, et al. RE-AIM evaluation of a one-year trial of a combined educational and environmental workplace intervention to lower salt intake in Switzerland. *Prev Med Rep.* 2019;16. 100982.

44. Meuleman Y, ten Brinke L, Kwakernaak AJ, et al. Perceived barriers and support strategies for reducing sodium intake in patients with chronic kidney disease: a qualitative study. *Int J Behav Med*. 2015;22:530-539.

45. Mattes RD, Donnelly D. Relative contributions of dietary sodium sources. *J Am Coll Nutr.* 1991;10:383-393.

46. Flesher M, Woo P, Chiu A, Charlebois A, Warburton DER, Leslie B. Self-management and biomedical outcomes of a cooking, and exercise program for patients with chronic kidney disease. *J Ren Nutr.* 2011;21:188-195.

47. de Brito-Ashurst I, Perry L, Sanders TAB, et al. The role of salt intake and salt sensitivity in the management of hypertension in South Asian people with chronic kidney disease: a randomised controlled trial. *Heart.* 2013;99:1256-1260.

48. Paes-Barreto JG, Barreto Silva MI, Qureshi AR, et al. Can renal nutrition education improve adherence to a low-protein diet in patients with stages 3 to 5 chronic kidney disease? *J Ren Nutr.* 2013;23:164-171.

49. Meuleman Y, Hoekstra T, Dekker FW, et al. Sodium restriction in patients with CKD: a randomized controlled trial of self-management support. *Am J Kidney Dis.* 2017;69:576-586.

50. Hendriksen MA, Hoogenveen RT, Hoekstra J, Geleijnse JM, Boshuizen HC, van Raaij JM. Potential effect of salt reduction in processed foods on health. *Am J Clin Nutr.* 2014;99:446-453.

51. McLean R, Hoek J, Hedderley D. Effects of alternative label formats on choice of high- and low-sodium products in a New Zealand population sample. *Public Health Nutr.* 2012;15:783-791.

52. Eyles H, McLean R, Neal B, et al. A salt-reduction smartphone app supports lower-salt food purchases for people with cardiovascular disease: findings from the SaltSwitch randomised controlled trial. *Eur J Prev Cardiol.* 2017;24:1435-1444.

53. Taylor DM, Fraser SDS, Bradley JA, et al. A systematic review of the prevalence and associations of limited health literacy in CKD. *Clin J Am Soc Nephrol*. 2017;12:1070-1084.

54. Amuta-Jimenez AO, Lo C, Talwar D, Khan N, Barry AE. Food label literacy and use among US adults diagnosed with cancer: results from a national representative study. *J Cancer Educ.* 2019;34:1000-1009.

55. Parekh N, Jiang J, Buchan M, Meyers M, Gibbs H, Krebs P. Nutrition literacy among cancer survivors: feasibility results from the Healthy Eating and Living Against Breast Cancer (HEAL-BCa) study: a pilot randomized controlled trial. *J Cancer Educ.* 2018;33:1239-1249.

56. Hakami R, Gillis DE, Poureslami I, FitzGerald JM. Patient and professional perspectives on nutrition in chronic respiratory disease self-management: reflections on nutrition and food literacies. *HLRP Heal Lit Res Pract*. 2018;2:e166-e174.

57. Begley A, Paynter E, Butcher L, Dhaliwal S. Effectiveness of an adult food literacy program. *Nutrients.* 2019;11:797.

58. Amouzandeh C, Fingland D, Vidgen HA. A scoping review of the validity, reliability and conceptual alignment of food literacy measures for adults. *Nutrients.* 2019;11:801.

59. Echeverri M, Anderson D, Nápoles AM, Haas JM, Johnson ME, Serrano FSA. Cancer health literacy and willingness to participate in cancer research and donate bio-specimens. *Int J Environ Res Public Health*. 2018;15:2091.