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The inflammatory effects of diet, nutritional status, and severity of chronic kidney disease at Bogor City Hospital

Efek inflamasi diet, status gizi dan derajat keparahan penyakit ginjal kronik di RSUD Kota Bogor

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Abstract

Diet and nutritional status play an important role in chronic kidney disease (CKD). Pro-inflammatory foods are linked to a decline in kidney function, whereas the nutritional status of obesity is a risk factor for CKD. This study aimed to analyze the relationship between (DII), nutritional status, and CKD severity. This cross-sectional study was conducted between April and May 2023 at Bogor City Hospital. A total of 64 patients with CKD were selected using accidental sampling. Consumption data were collected from the SQ-FFQ, nutritional status was assessed using Body Mass Index (BMI), and disease severity was assessed using creatinine and estimated glomerular filtration rate (eGFR) levels. Data were analyzed using ANOVA, Kruskal-Wallis, Pearson, and Spearman correlation tests. Results: All subjects had positive DII scores, their nutritional status was mostly in the normal range (59,4%), and almost all subjects had CKD stage 5 (95,3%). No relationships were found between the DII score and creatinine level (p= 0,986) and eGFR (p= 0,359). There was also no relationship between nutritional status and creatinine (p= 0,985) and eGFR (0,442). In conclusion, a positive DII score indicated that all subjects consumed more pro-inflammatory foods. Actions are needed to get CKD patients with CKD who consume more anti-inflammatory foods.

Keywords: Chronic kidney disease, dietary inflammatory index, nutritional status

Abstrak

Diet dan status gizi memegang peran pada penyakit ginjal kronik (PGK). Diet pro-inflamasi berhubungan dengan penurunan fungsi ginjal dan status gizi obesitas merupakan faktor risiko dari PGK. Penelitian ini bertujuan untuk menganalisis hubungan antara *Dietary Inflammatory Index (DII)* dan status gizi dengan derajat keparahan PGK. Penelitian ini merupakan penelitian *cross-sectional* yang dilaksanakan pada bulan April – Mei 2023 di RSUD Kota Bogor. Sejumlah 64 pasien PGK dipilih sebagai subjek dengan menggunakan teknik *accidental sampling*. Data konsumsi diperoleh dari SQ-FFQ, status gizi dinilai dari Indeks Massa Tubuh (IMT) dan derajat keparahan penyakit dinilai dari kreatini dan eGFR. Analisis data menggunakan uji ANOVA, Kruskal-Wallis, Pearson, dan Spearman. Semua subjek memiliki Skor DII positif, status gizi sebagian besar subjek dalam kisaran normal (59,4%) dan hampir semua subjek adalah pasien PGK stadium 5 (95,3%). Tidak ditemukan hubungan antara skor DII dengan kreatinin (p = 0,986) dan eGFR (0,359). Tidak ditemukan hubungan antara status gizi dengan kreatinin (p=0,985) dan eGFR (0,442). Kesimpulan, semua subjek memiliki skor DII positif (di atas 0), menunjukkan bahwa semua subjek mengonsumsi lebih banyak makanan pro-inflamasi. Diperlukan usaha agar pasien PGK lebih banyak mengkonsumsi makanan yang bersifat anti-inflamasi.

Kata Kunci: Penyakit ginjal kronik, *dietary inflammatory index*, status gizi

Introduction

Chronic kidney disease (CKD) is a global health concern worldwide. The worldwide prevalence of CKD is estimated at 13,4% (Lv & Zhang, 2019). The Indonesian Renal Registry (IRR, 2018) revealed that the crude incidence rate for stage 5 CKD patients requiring haemodialysis is 251 per million, and the crude prevalence rate for the entire Indonesian population is 499 per million. The prevalence of CKD in West Java province for individuals over 15 years of age is 0,48%, which is higher than the average prevalence for all provinces (Kemenkes, 2018). By 2040, CKD is projected to become the fifth most common cause of death globally (Foreman et al., 2018).

From the economic health perspective, the Health Insurance Administration Agency (BPJS) in 2019 showed as many as 1,93 million cases of kidney failure at a cost of 2,79 trillion. Even during the covid pandemic in 2020, there were still 1,79 million cases at a cost of 2,24 trillion patients who received kidney replacement therapy. The wide ranging health, social and economic effects of CKD make it essential to prioritize early detection, prevention and management of CKD (Kemenkes, 2018).

Chronic kidney disease (CKD) is defined as a persistent decline in kidney function that is accompanied by structural damage. The most reliable measure of overall kidney function is the glomerular filtration rate (GFR), which represents the total volume of fluid filtered by functioning nephrons within a specified time frame. The definition and classification of CKD have progress over years. Presently, international guidelines characterize CKD as a reduction in kidney function indicated by a glomerular filtration rate (GFR) of less than 60 mL/min per 1,73 m^2, the presence of kidney damage markers, or a combination of both, persisting for a minimum of three months, irrespective of the underlying etiology (Webster et al., 2017). CKD patients may not exhibit any symptoms or experience non-specific symptoms such as itching, weakness, and loss of appetite. Typically, the diagnosis is confirmed after abnormalities are detected in laboratory tests or when the symptoms become more severe (Webster et al., 2017). Serum creatinine test is a widely used method for evaluating kidney function. Patients with CKD show elevated serum creatinine (Alfonso et al., 2016). The estimated glomerular filtration rate (eGFR) has also been used to evaluate kidney function in patients (Gounden et al., 2018).

Inflammation is a response of the immune system that protects the body from injury. Inflammation protects the body by eliminating agents that cause damage and promoting tissue healing. But when the body receives continuous harmful stimuli, the inflammatory reaction fails to repair the damage and chronic inflammation occurs (Ricker & Haas, 2017). Numerous factors contribute to dysregulation of the immune system and activation of inflammation in chronic kidney disease, either as a result of the underlying disease or due to uraemia associated with CKD. Additional elements, such as lifestyle choices and dietary habits, also play a significant role in this process (Thaha & Widiana, 2019).

Dietary factors regulate chronic kidney inflammation. Nutrients that have anti-inflammatory effects, such as omega-3 fatty acids, fiber, and certain vitamins, are associated with better kidney health, a lower risk of albuminuria, and slower progression of kidney decline. In contrast, pro-inflammatory nutrients, such as saturated fatty acids and sugars, can lead to a deterioration in kidney function (Mazidi et al., 2018).

Nutritional status, in addition to nutrient intake, plays a significant role in CKD development. A high Body Mass Index (BMI) in obese people has been linked to a chronic pro-inflammatory state and is associated with high levels of circulating pro-inflammatory markers such as leptin, TNF-α, and IL6. Chronic inflammation is a pathophysiological factor that can explain the link between obesity and its role as a risk factor for CKD (Lakkis & Weir, 2018).

The Dietary Inflammatory Index (DII) evaluates the inflammatory potential of an individual's diet. It was developed through a comprehensive literature review, analyzing 1,943 studies that investigated the relationship between 45 food parameters and 6 inflammatory markers (IL-1β, IL-6, TNF-α, CRP, IL-4, and IL-10) (Kizil et al., 2016). The analysis identified 45 food parameters that were evaluated and assigned scores of +1, −1, or 0 based on their inflammatory properties, categorized as pro-inflammatory, anti-inflammatory, or neutral, respectively. Additionally, the quantity of articles and the type of study were used to assign weights to each of the 45 food parameters. This information facilitated the computation of a 'food parameter-specific overall inflammatory effect score,' which served as a multiplicative factor in the determination of the Dietary Inflammatory Index (DII) score (Almeida-de-Souza et al., 2018). The calculation of DII is briefly as follows: First, we subtracted the daily intake of individuals from each parameter by the global average intake, which was then divided by the global average intake deviation standard to obtain the Z Score value. The Z-score was converted to a percentile score. To obtain a symmetrical distribution centered at 0, the centralized percentile value was calculated by multiplying the percentile value by 2 and then subtracting it by 1. Then, the centralized percentile value for each parameter is multiplied by the "overall inflammatory effect" score, respectively to obtain the "food parameter-specific DII score". The last step is to add up all the "food parameter-specific DII scores" to get the overall DII score of the individual (Shivappa et al., 2014). A pro-inflammatory diet, as indicated by a high DII score, is associated with the severity (Mazidi et al., 2018).

Diet and nutritional status play an important role in kidney function and CKD severity. It is important to understand the relationship between the DII, nutritional status, and CKD severity. Knowing this relationship can provide information to patients, doctors, and related parties for the prevention and management of CKD in clinical practice. In Indonesia, no study has evaluated the inflammatory potential of diets using the DII score in patients with CKD. Evaluating the DII in the Indonesian population is crucial because differences in dietary habits, lifestyles, and environments with other populations may have different DII values. Therefore, this study should be conducted to provide valuable information to healthcare professionals, the general public, families, and patients with CKD.

Methods

This cross-sectional study aimed to investigate the relationship between the inflammatory potential of the diet (DII score), nutritional status, and CKD severity. The study was conducted between April and May 2023 at Bogor City Regional Hospital. Ethical clearance was obtained from the Health Research Ethics Committee of Bogor City Hospital (005/KEP-RSUD/EC/II/2023). Prior to the study, all participants provided informed consent and were informed that the data they provided were confidential.

Patients with CKD who visited Bogor City Hospital and met the inclusion criteria were selected for this study through accidental sampling. Being diagnosed with CKD by a doctor, age above 18 years, good general condition, laboratory creatinine data, and willingness to participate in the research by signing informed consent, patients and/or families can communicate well are the inclusion criteria for subjects. Subjects who withdrew or died during the study period were excluded from the study. We conducted interviews with 69 subjects; however, only 64 met the inclusion and exclusion criteria. The remaining five subjects were excluded from the analysis because of this study due to physical conditions that precluded the measurement of height and weight.

Food consumption data were collected through a validated Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) (Umar, 2020). The SQ-FFQ includes the types of food items, how often they are consumed, and the estimated amount of these foods in grams and household measurements. A food photo book was used to assist participants in recalling the amount of food they consumed. Then, the data analyzed using the Indonesia Food Database (Kemenkes, 2020), the United States Department of Agriculture food database (U.S. Department of Agriculture, 2024), and the Australian Food Composition Database (Food Standards Australia New Zealand, 2023). Nutritional status was determine by calculating Body Mass Index (BMI). eGFR was calculated using the CKD EPI formula (Inker et al., 2021) based on the serum creatinine values obtained from the medical records.

Consumption data from 40 nutrients and food parameters were used to calculate the DII scores. The 40 parameters included 34 nutrients and six foods, including vitamin B12, vitamin B6, β-carotene, caffeine, carbohydrate, cholesterol, energy, total fat, fiber, folic acid, garlic, ginger, iron, magnesium, monounsaturated fatty acid (MUFA), niacin, omega-3 fatty acid, omega-6 fatty acid, onion, protein, polyunsaturated fatty acid (PUFA), riboflavin, saturated fat (SAFA), selenium, thiamin, trans fat, turmeric, vitamin A, vitamin C, vitamin D, vitamin E, zinc, tea, flavan-3-ol, flavones, flavonols, flavanones, anthocyanidins, isoflavones, and pepper. Some of the nutrient and food parameters used in the original version of the DII calculation were not used in this study. Alcohol, saffron, thyme/oregano, and rosemary were not consumed by all subjects, and eugenol was not found in any of the food databases.

Consuming foods and nutritional components with anti-inflammatory properties contributes negative values to the DII score, whereas consuming components that promote inflammation contributes positive values. The DII scores of all components were added to obtain an individual DII score. Individuals who consume more nutrients and foods high in pro-inflammatory components will have a positive DII score (above 0), whereas those who consume more anti-inflammatory components will have a negative DII score (< 0) (Mazidi et al., 2018).

The data obtained were processed through questionnaire editing, coding, entry, and analysis. Data processing was performed using Microsoft Excel 2019 software and SPSS 25.0. The processed and analyzed data included subject characteristics, DII scores, BMI, and eGFR. The normality test was performed using the Kolmogorov-Smirnov test. Univariate and bivariate analyses were performed in this study. A descriptive test was performed on the variables included in the univariate analysis. Bivariate analysis was performed to assess the relationships between the research variables. Because creatinine has a normal data distribution, a Pearson correlation test was performed to determine the relationship between the DII score and creatinine level. While eGFR had an abnormal data distribution, a Spearman correlation test was used to determine the relationship between the DII score and eGFR. An analysis was also carried out to determine the differences in creatinine and eGFR values in the four nutritional status groups. The creatinine value had a normal data distribution; therefore, the ANOVA test was carried out to determine the difference in creatinine values in different nutritional status groups. The eGFR values had an abnormal data distribution; therefore, a Kruskal-Wallis test was performed to determine the difference in eGFR values in different nutritional status groups.

Result and Discussion

Characteristics Subject

This study included 64 patients with CKD at Bogor City Hospital. The characteristic data are presented in Table 1. The participants were 25 – 72 years old, and most were female (67,5%). A meta-analysis conducted by Hill et al. (2016), which included 75 global studies, revealed that the prevalence of PGK increases with age. Specifically, the prevalence of PGK among individuals aged 30–40 years was 13,7%, whereas in the 70–80 years age group, the prevalence was 27,9%. In Indonesia, research by Yuda et al (2021). indicated that the highest prevalence of PGK was observed in the young adult age range of 40 to 60 years. This finding aligns with the current study, which identified the majority of subjects aged 45–54-year age.

Approximately 67,2% of the patients had a history of hypertension. Hypertension is one of the leading causes of chronic kidney disease (CKD). A meta-analysis by Hill et al. (2016) also concluded that there was a significant relationship between hypertension and CKD. Prolonged high blood pressure leads to inflammation in kidney organs, resulting in decreased function and chronic kidney disease. Approximately 28,1% had a history of diabetes mellitus (DM), 62,5 subjects did not smoke (62,5%), and nutritional had a normal range (59,4%). Almost all the subjects had CKD stage 5 (95,3%).

Table 1. Characteristics of research subject (n=64)

Characteristics	n	%
Gender		
Male	24	37,5
Female	40	62,5
Age (year)		
25-34	10	15,6
35-44	10	15,6
45-54	24	37,5
55-64	14	21,9
65-74	6	9,4
Mean ± SD	48,8 ± 12,2	
Median	51,0	
History of Hypertension		
Yes	43	67,2
No	21	32,8
History of DM		
Yes	18	28,1
No	46	71,9

Smoking Habit		
Former smoker	22	34,4
Current smoker	2	3,1
Never smoker	40	62,5
CKD Staging		
Stage 3a	1	1,6
Stage 4	2	3,1
Stage 5	61	95,3
Nutritional Status (BMI)		
Thinnes	9	14,1
Normal	38	59,4
Overweight	5	7,8
Obesity	12	18,7

The Inflammatory Potential of Diet

Among the subjects in this study, isoflavones, vitamin A, and SAFA were the three components of DII with the highest anti-inflammatory properties, as indicated by their largest negative values (Table 2). This shows that isoflavones and vitamin A, which are anti-inflammatory components (produce negative values in the DII score calculation), were consumed in large amounts by the subjects.

Table 2. DII scores

DII component	DII score (n= 64) Mean ± SD
Isoflavon (mg)	-0,422 ± 0,400
Vitamin A (RE)	-0,180 ± 0,297
SAFA (g)	-0,162 ± 0,244
Total fat (g)	-0,146 ± 0,225
Trans fat (mg)	-0,136 ± 0,003
Energy (kcal)	-0,128 ± 0,097
Carbohydrate (g)	-0,067 ± 0,055
Vitamin B6 (mg)	-0,017 ± 0,277
Protein (g)	-0,016 ± 0,011
Kolesterol (g)	-0,016 ± 0,106
Vitamin B12 (mcg)	-0,013 ± 0,093
Fe (mg)	-0,008 ± 0,025
Riboflavin (mg)	-0,004 ± 0,054
MUFA (g)	0,008 ± 0,006
Tiamin (mg)	0,015 ± 0,086
Niasin (mg)	0,042 ± 0,186
Omega-6 (g)	0,069 ± 0,075
Anthocyanidin (mg)	0,079 ± 0,001
Caffeine (mg)	0,080 ± 0,019
Folic acid (mcg)	0,083 ± 0,172
Pepper (g)	0,108 ± 0,001
Selenium (mcg)	0,135 ± 0,070
Garlic (g)	0,143 ± 0,229
PUFA (g)	0,156 ± 0,264
Zn (mg)	0,196 ± 0,221
Flavonones (mg)	0,227 ± 0,120
Onion (g)	0,251 ± 0,040
Turmeric (mg)	0,254 ± 0,248
Omega-3 (g)	0,261 ± 0,125
Tea (g)	0,275 ± 0,201
Ginger (g)	0,290 ± 0,004
Beta carotene (mcg)	0,298 ± 0,428
Flavan 3 ol (mg)	0,301 ± 0,004
Vitamin C (mg)	0,321 ± 0,195
Mg (mg)	0,335 ± 0,147
Vitamin D (mcg)	0,343 ± 0,116
Vitamin E (mg)	0,349 ± 0,286
Flavones (mg)	0,440 ± 0,000
Flavonols (mg)	0,452 ± 0,009
Fibre (g)	0,596 ± 0,317
Mean DII score	4,793 ± 1,589
Anti-inflammatory, n (%)	0 (0)
Pro-inflammatory, n (%)	64 (100)

Meanwhile, SAFA, a pro-inflammatory component (providing a positive value if consumed), was consumed by subjects in low amounts, thus having a negative effect on the DII score calculation. The high consumption of isoflavones in the subjects was likely related to the high consumption of soy-derived foods such as tofu and tempeh. The high intake of vitamin A is probably attributable to its numerous dietary sources, which include commonly consumed foods such as eggs, fish, liver, carrots, green leafy vegetables, and sweet potatoes. The low intake of SAFA is attributable to the avoidance of various food sources rich in SAFA, including fatty meats, dairy products, and highly processed foods.

Fiber, flavonols, and flavones were the three components of DII that were the most pro-inflammatory (giving a positive value) in this study. The consumption of these three components is anti-inflammatory (giving a negative value), and the positive value seen in the calculation of the subject's DII score for these three components indicates a low intake of fiber, flavonols, and flavones. This low consumption of fiber, flavonols, and flavones may be due to a lack of intake of certain vegetables and fruits, which are restricted to patients with CKD.

The results of this study were slightly different from those of Semira (2023), who found that the most anti-inflammatory components were isoflavones, vitamin B12, and vitamin C, and the most pro-inflammatory components were flavones, tea, and ginger. The research subjects in Semira's study were breast cancer patients who had no dietary restrictions, whereas those in this study were stage 5 CKD patients who faced limitations in their food choices.

In this study, the subjects' DII scores were in the range of 0,79 – 7,98 with an average value of 4,79 ± 1,5. The DII scores for all subjects were positive (above 0), indicating a higher intake of anti-inflammatory pro-inflammatory components. In contrast with research by Mazidi et al. (2018) which reported DII scores ranging from -5,66 to 4,33 in their study of 1634 CKD patients, the subjects in our study exhibited more pro-inflammatory tendencies. The observed differences in results may be attributed to variations in the research populations, dietary patterns, and parameters of the Dietary Inflammatory Index (DII) used. Specifically, the study conducted by Mazidi et al. (2018) focused on an American population and utilized 27 of the 45 parameters available for the DII score.

The DII score, which was pro-inflammatory in all subjects in this study, was probably because the majority of the subjects in this study (95,3%) were patients with stage 5 CKD who experienced decreased food intake and limited food choices due to disease progression. Certain vegetables and fruits, known for their anti-inflammatory properties and nutrient contents, are commonly restricted to patients with CKD.

The severity of CKD

This study evaluated disease severity by analyzing the serum creatinine levels and eGFR. Based on the findings of laboratory tests, the mean creatinine level among the subjects was 8,89 ± 3,78 mg/dl, while the mean eGFR was 7,29 ± 4,86 ml/min/1,73 m^2. The creatinine values of the subjects in this study were closely similar to a study by Alfonso et al. (2016) which examined creatinine serum in 35 stage 5 CKD patients and found that the average creatinine level of the research subjects was 6,9 mg/dL, with the lowest creatinine level being 1,67 mg/dL and the highest creatinine level being 17,7 mg/dL. The average eGFR of the subjects in this study was 7,29 ± 4,86 with a maximum and minimum value of 2 – 36. The average eGFR of the subjects was at CKD stage 5 (< 15 ml/min/1,73 m^2).

The majority (95,3%) of the subjects had stage 5 CKD, also referred to as end-stage kidney disease, which is characterized by severe impairment of kidney function. However, this condition has several limitations. For instance, owing to their reduced ability to eliminate nutrients, patients are required to restrict their intake of certain foods. If the restricted foods are those with anti-inflammatory properties, this may result in a low consumption of anti-inflammatory foods, which is not beneficial for patients experiencing high levels of inflammation, such as those with stage 5 CKD.

Inflammatory Potential of Diet and CKD Severity

The DII score describes the inflammatory potential derived from daily dietary intake. High DII scores in most subjects in this study indicated that their diet was pro-inflammatory, leading to heightened inflammation within the body. Patients with chronic kidney disease (CKD), characterized by high creatinine levels and low eGFR, already experience elevated inflammation due to disease progression, comorbidities, and complications. Consumption of foods with inflammatory potential exacerbates inflammation in the body. However, this study did not find any relationship between the inflammatory potential of diet, as reflected in the DII score, and the severity of CKD, as reflected in the creatinine and eGFR values (Table 3). There was no relationship between the DII score and creatinine (p =0,986) and there was no relationship between DII score and eGFR (p=0,359).

We also categorized the subjects into three tertile DII score groups to compare CKD severity (creatinine and eGFR) among the three groups; however, no significant difference was found (Table 4). There was no difference in creatinine (p=0,195) and eGFR (p=0,06) among the three tertile DII score groups. Meanwhile, research by Rouhani et al. (2019) in Iran, which examined 221 patients with CKD, found that there was a risk of increasing CKD severity in subjects in the highest tertile of DII scores. The differences in findings could be due to differences in the sample size, socio-demographics, and severity of the disease. In our study, 95,3% of the subjects were CKD stage 5 patients, whereas the subjects in Rouhani's study were mostly (60%) CKD stage 3 patients.

Table 3. Relationship between inflammatory potential of diet (DII score) and CKD severity (Creatinine and eGFR)

Variable	The inflammatory potential of diet (DII Score)	
	r	p
Creatinine	-0,002[P]	0,986
eGFR	0,116[S]	0,359

[P]: Pearson's correlation test. [S]: Spearman correlation test

These anti-inflammatory foods are not a typical component of the Indonesian diet. However, the DII score calculation does not include popular high-antioxidant and anti-inflammatory foods commonly consumed by Indonesians, such as moringa leaves, okra, black cumin, and chilies. Various food items that were not prepared by the subjects themselves may also have affected the outcomes of this study, particularly spices such as garlic, onions, ginger, turmeric, and pepper. The subjects were unable to specify the amount of seasonings consumed in dishes that were not prepared by them.

The majority of subjects (95,3%) with stage 5 CKD may have contributed to the absence of a correlation between the DII score and disease severity. Socioeconomic conditions within the community could be a factor, as early stage CKD patients may remain undiagnosed and fail to seek medical care, resulting in only late-stage CKD patients visiting hospitals.

Table 4. The differences in eGFR level among DII score tertile

Variable	DII score tertile			p-value
	T1 (≤ 4,26) n (21)	T2 (4,26 – 5,46) n (22)	T3 ≥ 5,47 n (21)	
Creatinine	9,80 ± 3,63	7,76 ± 2,93	9,16 ± 4,53	0,195[A]
eGFR	5,95 + 3,43	8,86 + 6,83	7,00 + 3,00	0,06 [K]

[A] : ANOVA test. [K]: Kruskal-Wallis test

Nutritional Status and Disease Severity (Creatinine and eGFR)

Nutritional status can be assessed using Body Mass Index (BMI), which is calculated by comparing an individual's weight in kilograms with the square of their height in meters (Kemenkes, 2018). The majority of the subjects (59%) had a normal BMI, 18,7% were classified as obese, and 14,1% were thin. These findings are comparable to those of Suwitra & Dewiana (2018), who examined 38 CKD patients who had undergone hemodialysis for over five years at Sanglah General Hospital in Denpasar. In their study, the distribution of patients was as follows: 55,3% had a normal weight, 28,9% were classified as obese, and 15,8% were thin.

High BMI is a significant risk factor for chronic the kidneys. Increased metabolic demand experienced by obese individuals leads to kidney hyperfiltration. This elevation in intraglomerular pressure can result in kidney damage and an increased risk of developing CKD (Kovesdy et al., 2017). Obesity is also a risk factor for chronic kidney disease (CKD) due to the chronic inflammation induced in the kidneys (Lakkis & Weir, 2018).

There is a concept known as the obesity paradox in non-communicable diseases, including CKD. Interestingly, while high BMI is considered a risk factor for CKD, it is also associated with better survival rates. Overnutrition is not the only contributor to kidney damage; malnutrition also plays a significant role in the development of kidney disease, and a low body mass index (BMI) can lead to inflammation, which is a well-known risk factor (Câmara et al., 2017).

Table 5. Differences in the severity of CKD (creatinine and eGFR) among nutritional status groups

Nutritional status	n (%)	Creatinine (mg/dl)	p-value	eGFR (ml/min/1,73 m2)	p-value
Thin	10 (15,6)	7,41±12,94	0,458[A]	8,40 ± 3,59	0,545[K]
Normal	35 (54,7)	9,37 ± 3,62		6,00 (3,00 –36,00)	
Overweight	5 (7,8)	7,72 ± 1,50		5,00 (5,00 –10,00)	
Obesity	14 (21,9)	9,17 ± 5,03		7,50 ± 4,47	

[K]: Kruskal–Wallis test. [A]: One way anova test

In this study (Table 5), we were unable to determine a relationship between nutritional status and CKD severity. The correlation test indicated that there was no relationship between BMI and creatinine level (p = 0,985) or eGFR (p = 0,442). There were also no significant differences in creatinine level (p=0,458) and eGFR (p=0,545) between the groups in terms of nutritional status.

The findings of this study were different from those of a study by Nifalo (2020) that investigated 129 patients with CKD at Fatmawati Central General Hospital, South Jakarta, and concluded that there was a significant relationship between BMI and kidney function (p=0,028). In addition to BMI, there are measurements indicate the presence of central fat and have been associated with various chronic conditions, including CKD. A study conducted by Ferdina & Sembiring (2022) on adult subjects in Kalimantan, utilizing data from Riskesdas 2018, aimed to compare several obesity measurements, namely BMI, waist-to-height ratio (WtHR), and waist circumference (WC), in predicting conditions such as diabetes mellitus (DM), heart disease, hypertension, and CKD. The findings indicated that a high WtHR was linked to several chronic diseases, including CKD, whereas BMI showed a significant relationship only with DM and hypertension.

Owing to the physical limitations of the subjects we studied, we focused solely on measuring height and weight to calculate the BMI. Given that WtHR is more effective in predicting CKD, future studies should consider using WtHR to better represent the nutritional status of CKD patients.

This study had several limitations, including the fact that its cross-sectional design limited the results to an association rather than establishing causation. Another limitation is the possibility that confounding factors were not measured in this study.

Conclusion

No relationships were found between DII score, nutritional status, and disease severity. It was found that all subjects consumed more pro-inflammatory food; therefore, it is necessary to provide education to subjects and other CKD patients regarding the importance of consuming anti-inflammatory foods. The education provided may take the form of seminars, distribution of printed educational materials, or individual nutrition consultations. There is also an urgent need to develop anti-inflammatory foods recommended for patients with CKD.

Further research involving more subjects, variations in CKD staging, and different design studies are needed. It is also necessary to modify the DII score by including typical Indonesian foods and eliminating foods/nutrients that are rarely consumed in Indonesia.

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