

Association between Uric Acid Level and Chronic Kidney Disease in Middle-aged and Elderly Subjects in Southern Taiwan

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Abstract

Objectives: The purpose of this study was to examine the relationship between uric acid level and chronic kidney disease (CKD) in the middle-aged and elderly population in Southern Taiwan. **Methods:** This was a cross-sectional study of 9,450 people recruited from a population that received free adult health examinations provided by a hospital in a district in Kaohsiung City between July 2005 and July 2011. CKD diagnosis standards followed those set by the U.S. National Kidney Foundation kidney disease outcomes quality initiative (K/DOQI) in 2002. The relationship between hyperuricemia and CKD was examined and multiple logistic regression analysis was used to identify factors affecting CKD. **Results:** The prevalence of hyperuricemia amongst patients with CKD was 45.1%, with the level of uric acid(UA) concentration increasing at an abnormal rate at different stages of CKD. The results of multiple logistic regression analysis of UA concentrations showed that men, aged 65 and above and metabolic syndrome were at

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risk of CKD. On the other hand, daily consumption of fruits and vegetables served as a protective factor. Based on the different categories of uric acid, we discovered that regardless of the regression model used, whether I, II, or III, the risk of contracting CKD increased as the UA concentration level increased.

Keywords: Chronic kidney disease, uric acid, metabolic syndrome.

1 Introduction

Because of the continuing advances in medicine, many elderly and chronically ill patients no longer die of early-stage cardiovascular complications in their early stages of life. Instead, the lives of such patients are often extended until renal dysfunction develops and becomes fatal. The patients suffer as a result of renal dysfunction, as the deterioration of renal functioning can necessitate hemodialysis treatment or organ transplantation. These are the main reasons for the increasing number of hemodialysis patients in recent years in Taiwan. The population of end stage renal disease (ESRD) patients is increasing worldwide [1,2], and there are currently about 60,000 people receiving long-term chronic peritoneal dialysis treatment in Taiwan, with the number of patients increasing by about 2000 each year. This significantly influences the health of the Taiwanese people overall and has caused National Health Insurance expenditures to reach approximately 350,000,000 NTD per year [3]. Chronic kidney disease (CKD) is even more prevalent than ESRD in Taiwan, and since the progression of CKD to ESRD not only increases the death rate due to cardiovascular complications but also places burdens on individuals, families, and society, CKD has become a target for disease prevention efforts in countries worldwide.

Routine tests and treatment can detect, slow down and prevent the deterioration of CKD and the risk of cardiovascular and other complications, thereby enhancing the quality of life and the survival rate [4]. The new K-DOQI (kidney disease outcomes quality initiative) guide also uses estimated glomerular filtration rate (eGFR) as a classifying standard for the definition and level of CKD to facilitate epidemiological screening and clinical diagnosis. This new concept has been widely accepted in the nephrology community [5]. In recent years, large-scale epidemiological studies have found correlations among hyperuricemia, hyperpiesia, diabetes, obesity, metabolic syndrome (MetS), and CKD. Further analytical results showed that increases in uric acid (UA) also increased the death rate from cardiovascular diseases and accelerated renal dysfunction [6,7]. Studies on UA and CKD have identified UA as a risk factor for CKD that accelerates renal dysfunction and increases the rates of CKD and kidney failure [7-9]. Madero et al. found that patients with stage 3 CKD have a poorer prognosis if they also have higher levels of UA [10]. Renal dysfunction induces a higher risk of ESRD, hemodialysis, and cardiovascular diseases, and is also the main cause of death in CKD. In seeking to prevent and cure CKD, it is important to understand the risk factors for CKD. The prevalence of CKD and hyperuricemia in Taiwan is higher than in Western countries [11], and the farther south one goes in Taiwan, the higher the prevalence rates. The incidence and prevalence rates of CKD in Kaohsiung, Chiayi, and Tainan are significantly higher than in any other area in Taiwan [12]. Such regional variations and high prevalence rates are worthy of further analysis and discussion. Most of the studies on correlations between the concentration of UA and CKD have used clinical patients and animal as

subjects[13], and only a few have targeted the elderly in the community to investigate the effect of high UA levels on CKD. The present study analyzed and discussed correlations between the concentration of UA and CKD in people aged over 40 in southern Taiwan, due to the region's status as an endemic area for kidney disease.

2 Methods

The present study used a cross-sectional design and collected data from middle-aged and elderly people aged 40 and above who participated in a free adult health examination from July 1, 2005 to July 31, 2011 in Kaohsiung. The total sample size was 12,583, with a valid sample size of 9,450 after deducting the number of those who did not undergo the complete physical examination and biochemical blood examination or who had repeated screening.

The research instruments used were an adult health examination questionnaire and the health examination data. The physical examination included the following: blood pressure and anthropometric measurements, including height, weight, and body mass index (BMI). Height was measured to the nearest 0.1 cm, without shoes, using a stadiometer. Weight was measured in light clothing, without shoes, using a beam balance scale, and was recorded to the nearest 0.1kg. BMI was calculated as weight (kg) divided by height² (m²). Well-trained nurses measured the systolic blood pressure (SBP) and diastolic blood pressure (DBP) two times in the left arm of seated participants according to a standardized protocol. A third BP measurement was made if the first two BP readings differed by more than 10 mm Hg. The average of the two closest readings was calculated to determine the reported BP for each participant.

The items in the blood examination included total cholesterol, triglyceride, UA, fasting plasma glucose(FPG), and creatinine (Cr). The sample was venous blood drawn after 8 hours of fasting, and was sent to the lab within an hour and analyzed by a Hitachi-7070 biochemical analyzer and XT-1800i globulimeter.

Definition of terms: (1) Definition of CKD: In the present study, the GFR was estimated using the Modification of Diet in Renal Disease (MDRD), and CKD was grouped into 5 stages based on the categorization of CKD by the National Kidney Foundation, Inc.: a patient whose eGFR ≥ 90 ml/min/1.73m² with proteinuria was in stage 1; those with eGFR ≥ 60 -89 ml/min/1.73m² with proteinuria were in stage 2; those with eGFR ≥ 30 -59 ml/min/1.73m² were in stage 3; those with eGFR ≥ 15 -29ml/min/1.73m² were in stage 4; those with eGFR < 15 ml/min/1.73m² were in stage 5. (2) In order to understand the current international classification of UA as a criterion of elevated UA, the present study classified the serum UA level into (A) UA > 7.0 mg/dL for males and UA > 6.0 mg/dL for females [3,13,14]; (B) 3 subgroups in light of the concentration of UA: (a) UA < 7 mg/dL, (b) 7 mg/dL \leq UA < 9 mg/dL, (c) UA ≥ 9 mg/dL [7]. (C) 4 subgroups among males: (a) UA < 5 mg/dL, (b) 5 mg/dL \leq UA < 6 mg/dL, (c) 6 mg/dL \leq UA < 7 mg/dL, and (d) UA ≥ 7 mg/dL. In females: (a) UA < 4 mg/dL, (b) 4 mg/dL \leq UA < 5 mg/dL, (c) 5 mg/dL \leq UA < 6 mg/dL, and (d) UA ≥ 6 mg/dL [15]. (3) The MetS was defined according to the criteria set by the Bureau of Health Promotion, Department of Health in 2007. Since waist circumference (WC) and high density lipoprotein cholesterol (HDL-C) were not routine inspection items in the previous health examination, the present study

referred to other research methods and took BMI as a replacement for WC and total cholesterol as a replacement for HDL-C [16]. The remaining components of MetS included, (i) elevated blood pressure, defined as blood pressure of at least 130/85 mm Hg or use of antihypertensive medication; (ii) elevated triglycerides, defined as serum triglycerides of at least 150 mg/dL; and (iii) elevated FPG, defined as FPG of 100 mg/dL or more or use of drug treatment for elevated glucose. The MetS was defined as the presence of 3 or more of these components.

This study was approved by the institutional review board in Meiho University before data collection.

The present study analyzed data using SPSS 17.0 (SPSS for Windows release 17.0), with a significance level of $\alpha = .05$. Descriptive statistics used the average value, the standard deviation, the frequency distribution, and the percentage criterion. Inferential statistics applied the Chi-square and multiple logistic regression model for analytics.

3 Main Results

Correlation analysis indicated that males, aged 65 and above, without the habits of a daily consumption of vegetables and fruits and exercising 3-5 times a week, had a higher risk of CKD. The analysis results were statistically significant.

Analysis of the factors of MetS and its components showed that CKD patients suffered from a higher risk of elevated blood pressure, elevated triglyceride, obesity, and MetS than non-CKD patients ($p < .001$). Comparisons among groups of patients with different concentrations of UA and CKD showed that CKD patients had a higher rate of high UA levels than non-CKD patients (Table 1).

The present study further divided CKD into 5 stages according to eGFR and the degree of injury to the kidney. The analysis results (Table 2) indicated that CKD had correlations with gender, age, exercise and smoking habit, and achieved statistical significance ($p < .001$). Analysis of MetS and its components found that obesity, elevated blood pressure, elevated triglyceride, elevated FPG and having MetS had a higher risk of CKD patients from stage 1 to stage 5; these results were statistically significant. The abnormal rates of kidney injury in stages 3, 4, and 5 of CKD increased with the increasing concentration of UA; however, such a change was not found in stages 1 and 2 of CKD. The present study performed multiple logistic regressions by categorizing the concentration of UA and analyzing the data in regression models I, II, and III (Table 3) to analyze the correlation with CKD and UA. The results showed that factors including male, aged over 65, and MetS were risk factors for CKD, whereas daily vegetable and fruit consumption was a protective factor. In terms of the different groups of UA, we found abnormality in UA was a risk factor for CKD in regression models I, II, and III. The risk of CKD was up to 6.41 times greater (95% CI= 5.17-7.94) (Model II) if $UA \geq 9\text{mg/dL}$. In model III we also found that the risks of CKD increased with the increasing concentration of UA; the odds ratio (ORs) were 1.22 times, 1.59 times, and 3.82 times.

4 Labels of Tables

Table 1: Correlation Analysis of Demographic Characteristics, Lifestyle Factors, Biochemistry Exam Results and Chronic Kidney Disease (n=9450)

Variables	NO CKD (n=6757, 71.5%)		CKD (n=2693, 28.5%)		P Value
	Number	Percentage	Number	Percentage	
Gender					<.001
Male	2838	68.2	1325	31.8	
Female	3919	74.1	1368	25.9	
Age					<.001
40-64 Years	4772	82.7	998	17.3	
Above 65	1985	53.9	1695	46.1	
Daily Vegetable and Fruit Intake^a					0.007
Yes	4548	72.4	1735	27.6	
No	2209	69.8	958	30.2	
Exercise^b					<.001
No	4677	72.5	1773	27.5	
3-5 times a week	2080	69.3	920	39.7	
Smoking^c					0.208
No	5808	71.2	2346	28.8	
Yes	933	72	363	28	
Corpulence					<.001
$18.5 \leq \text{BMI} < 26.9 \text{ Kg/m}^2$	5070	73.4	1839	26.6	
$\text{BMI} \geq 27 \text{ Kg/m}^2$	1435	66.4	726	33.6	
Blood Pressure Elevation (mmHg)^d					<.001
Normal	2693	82.5	573	17.5	
Abnormal ($\geq 130/85 \text{ mmHg}$)	4064	65.7	2120	34.3	
Cholesterol					0.359
Normal	3613	71.1	1468	28.9	
Abnormal ($\geq 200 \text{ mg/dL}$)	3144	72	1225	28	
Triglyceride					<.001
Normal	5049	73.7	1800	26.3	
Abnormal ($\geq 150 \text{ mg/dL}$)	1708	65.7	893	34.3	
Blood Sugar Elevation^e					<.001
Normal	3354	77.8	956	22.2	
Abnormal ($\geq 100 \text{ mg/dL}$)	3403	66.2	1737	33.8	

Table 1: Correlation Analysis of Demographic Characteristics, Lifestyle Factors, Biochemistry Exam Results and Chronic Kidney Disease (n=9450) (Cont'd)

Variable	NO CKD (n=6757, 71.5%)		CKD (n=2693, 28.5%)		P Value
	Number	Percentage	Number	Percentage	
Metabolic Syndrome					<.001
No (Less than < 3 items of abnormality)	4340	75.5	1412	24.5	
Yes (More than ≥ 3 items of abnormality)	2417	65.4	1281	34.6	
High UA					<.001
Normal	5089	79.4	1320	20.6	
Abnormal (Male > 7, Female > 6mg/dL)	1668	54.9	1373	45.1	
Subgroups of UA^f					<.001
tertile 1	5510	77.8	1570	22.2	
tertile 2	1099	57.5	811	42.5	
tertile 3	148	32.2	312	67.8	
Subgroups of UA^g					<.001
Quartile 1	1036	83.7	202	16.3	
Quartile 2	1908	81.5	434	18.5	
Quartile 3	1976	76.7	601	23.3	
Quartile 4	1837	55.8	1456	44.2	

Note: Analyzed by Chi-square test, 2-tailed test, significance level $\alpha=.05$.

a Daily vegetable and fruit intake: 3 kinds of vegetables, 2 kinds of fruit

b Exercise: More than 30 minutes each time

c Smoking: Currently smoking

d Blood pressure elevation $\geq 130/85$ mmHg or currently taking antihypertensive drugs

e Blood sugar elevation ≥ 100 mg/dl or currently taking oral hypoglycemic agent

f Subgroups of UA tertile1: UA < 7mg/dL, tertile 2: 7mg/dL \leq UA < 9mg/dL

Tertile 3: UA ≥ 9 mg/dL

g Subgroups of UA Quartile1: Male UA < 5mg/dL, Female UA < 4mg/dL,

Quartile2: Male 5mg/dL \leq UA < 6mg/dL, Female 4mg/dL \leq UA < 5mg/dL

Quartile3: Male 6 mg/dL \leq UA < 7mg/dL, Female 5mg/dL \leq UA < 6mg/dL

Quartile4: Male UA ≥ 7 mg/dL, Female UA ≥ 6 mg/dL

Table 2: Correlation Analysis of Demographic Characteristics, Lifestyle Factors and Stage of Chronic Kidney Disease (n=9450)

Variable	non-CKD (n=6757)		Stage 1 (n=202)		Stage 2 (n=902)		Stage 3 (n=1417)		Stage 4 (n=107)		Stage 5 (n=65)		P Value
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	
Gender													<.001
Male	2838	68.2	78	1.9	461	11.1	717	17.2	43	1	26	0.6	
Female	3919	74.1	124	2.3	441	8.3	700	13.2	64	1.2	39	0.7	
Age													<.001
40-64 Years	4772	82.7	181	3.1	435	7.5	349	6	16	0.3	17	0.3	
Above 65	1985	53.9	21	0.6	467	12.7	1068	29	91	2.5	48	1.3	
Daily Vegetable and Fruit^a													0.113
Yes	4548	72.4	127	2	606	9.4	891	13.8	74	1.1	54	0.8	
No	2209	69.8	75	2.4	312	9.9	507	16	37	1.2	27	0.9	
Exercise^b													<.001
No	4677	72.5	148	2.3	228	9.6	362	15.2	38	1.6	27	1.1	
3-5 times a week	2080	69.3	54	1.8	296	9.9	526	17.5	33	1.1	11	0.4	
Smoking^c													<.001
No	5808	71.2	166	2	757	9.3	1266	15.5	95	1.2	62	0.8	
Yes	949	73.2	36	2.8	145	11.2	151	11.7	12	0.9	3	0.2	

Table 2: Correlation Analysis of Demographic Characteristics, Lifestyle Factors, Biochemistry Exam Results and Chronic Kidney Disease(n=9450) (Cont'd)

Variable	non-CKD (n=6757)		Stage 1 (n=202)		Stage 2 (n=902)		Stage 3 (n=1417)		Stage 4 (n=107)		Stage 5 (n=65)		P Value
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	
Blood Pressure Elevation^d													<.001
Normal	2693	82.5	81	2.5	138	4.2	328	10	17	0.5	9	0.3	
Abnormal ($\geq 130/85$ mmHg)	4064	65.7	121	2	764	12.4	1089	17.6	90	1.5	56	0.9	
Cholesterol													0.311
Normal	3613	71.1	108	2.1	472	9.3	787	15.5	59	1.2	42	0.8	
Abnormal (≥ 200 mg/dL)	3144	72	94	2.2	430	9.8	630	14.4	48	1.1	23	0.5	
Triglyceride													<.001
Normal	5049	73.7	132	1.9	603	8.8	960	14	64	0.9	41	0.6	
Abnormal (≥ 150 mg/dL)	1708	65.7	70	2.7	299	11.5	457	17.6	43	1.7	24	0.9	
Blood Sugar Elevation^e													<.001
Normal	3354	77.8	67	1.6	332	7.7	508	11.8	26	0.6	23	0.5	
Abnormal (≥ 100 mg/dL)	3403	66.8	135	2.6	570	11.1	909	17.7	81	1.6	42	0.8	
Metabolic Syndrome													<.001
No (Less than <3 items of abnormality)	4340	75.5	107	1.9	451	7.8	774	13.5	45	0.8	35	0.6	
Yes (More than ≥ 3 items of abnormality)	2417	65.4	95	2.6	451	12.2	643	17.4	60	1.7	30	0.8	

Table 2: Correlation Analysis of Demographic Characteristics, Lifestyle Factors, Biochemistry Exam Results and Chronic Kidney Disease(n=9450) (cont'd)

Variable	non-CKD (n=6757)		Stage 1 (n=202)		Stage 2 (n=902)		Stage 3 (n=1417)		Stage 4 (n=107)		Stage 5 (n=65)		P Value
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	
Corpulence													<.001
18.5 ≤ BMI < 26.9 Kg/m ²	5232	73.4	135	1.9	650	8.9	1058	14.5	72	1	52	0.7	
BMI ≥ 27kg/m ²	1435	66.4	67	3.1	252	11.7	359	16.6	35	1.6	13	0.6	
High UA													<.001
Normal	5089	79.4	164	2.6	568	8.9	554	8.6	20	0.3	14	0.2	
Abnormal (Male > 7, Female > 6mg/dL)	1668	54.9	38	1.2	334	11	863	28.4	87	2.9	51	1.7	
Subgroup of UA^f													<.001
tertile 1	5510	77.8	172	2.4	660	9.3	688	9.7	30	0.4	20	0.3	
tertile 2	1099	57.5	26	1.4	201	10.5	527	27.6	32	1.7	25	1.3	
tertile 3	148	32.2	4	0.9	41	8.9	202	43.9	45	9.8	20	4.3	
Subgroup of UA^g													<.001
Quartile 1	1036	83.7	40	3.2	91	7.4	68	5.5	1	0.1	2	0.2	
Quartile 2	1908	81.5	58	2.5	204	8.7	163	7	7	0.3	2	0.1	
Quartile 3	1976	76.7	60	2.3	241	9.4	284	11	9	0.3	7	0.3	
Quartile 4	1837	55.8	44	1.3	366	11.1	902	27.4	90	2.7	54	1.6	

a Daily vegetable and fruit intake: 3 kinds of vegetables, 2 kinds of fruit

b Exercise: More than 30 minutes each time

c Smoking: Currently smoking.

d Blood pressure elevation ≥ 130/85mmHg or currently taking antihypertensive drug

e Blood sugar elevation ≥ 100mg/dl or currently taking oral hypoglycemic agent

f Subgroups of UA tertile1: UA < 7mg/dL, tertile2: 7mg/dL ≤ UA < 9mg/dL tertile3: UA ≥ 9mg/dL

g Subgroups of UA Quartile 1: Male UA < 5mg/dL, Female UA < 4mg/dL,

Quartile 2: Male 5mg/dL ≤ UA < 6mg/dL, Female 4mg/dL ≤ UA < 5mg/dL

Quartile 3: Male 6 mg/dL ≤ UA < 7mg/dL, Female 5mg/dL ≤ UA < 6mg/dL

Quartile 4: Male UA ≥ 7mg/dL, Female UA ≥ 6mg/dL

Table 3: Regression Analysis of Risk Factors of CKD

Item	β	wald	OR (95%CI)	P value
Model I				
Gender ^a	0.15	9.86	1.16(1.06-1.28)	0.002
Age ^b	1.36	755.85	3.92 (3.56-4.32)	<.001
Daily Vegetable and Fruit Intake ^c	-0.18	11.98	0.83(0.750-0.92)	0.001
Metabolic Syndrome ^d	0.22	19.55	1.25(1.13-1.38)	<.001
High UA ^d	1.05	423.15	2.870(2.59-3.17)	<.001
Model II				
Age	1.37	757.2	3.94(3.57-4.34)	<.001
Daily Vegetable and Fruit Intake	-0.16	9.35	0.85(0.76-0.94)	0.002
Metabolic Syndrome	0.25	25.22	1.29(1.16-1.42)	<.001
tertile 2 ^e	0.87	225.39	2.38(2.13-2.67)	<.001
tertile 3 ^e	1.85	287.28	6.41(5.17-7.94)	<.001
Model III				
Gender	0.17	11.74	1.18(1.07-1.30.)	0.001
Age	1.37	759.87	3.95(3.58-4.35)	<.001
Daily Vegetable and Fruit Intake	-0.18	12.78	0.82(0.74-0.91)	0.001
Metabolic Syndrome	0.19	15.14	1.21 (1.10-1.34)	<.001
Quartile 2 ^f	0.2	4.26	1.22(1.01-1.48)	0.039
Quartile 3 ^f	0.46	24.87	1.59(1.32-1.92)	<.001
Quartile 4 ^f	1.34	226.58	3.82(3.21-4.55)	<.001
Note 1: Analyzed by stepwise regression analysis. Considered variables include age, UA, gender, exercising habit, smoking habit, metabolic syndrome, daily vegetable and fruit intake.				
Note 2: Dependent variable: CKD, 1. Suffering from CKD; 0. Not Suffering from CKD				
a: gender: Male=1, Female=0 b: Age: Above 65 Years =1 · 40-64 Years=0				
c: Daily Vegetable and Fruit Intake: 3 kinds of vegetables and 2 kinds of fruit everyday =1, No =0; Exercise 3-5 times =1, No exercise=0				
d: abnormality in uric acid and metabolic syndrome=1, Normal=0; Smoking=1, No smoking=0				
e: subgroups of UA tertile1:UA < 7mg/dL, tertile 2:7mg/dL≤UA < 9mg/ dL, tertile 3:UA≥9mg/dL				
f: subgroups of UA Quartile 1: Male UA < 5mg/dL, female UA < 4mg/dL				
Quartile 2: Male 5mg/dL≤UA < 6mg/dL, female 4mg/dL≤UA < 5mg/dL				
Quartile3: Male 6 mg/dL≤UA < 7mg/dL, female 5mg/dL≤UA < 6mg/dL				
Quartile 4: Male UA≥7mg/dL, female UA≥6mg/dL				

5 Discussion

The prevalence of CKD is higher in the southern part of Taiwan than in other areas in Taiwan. The present study analyzed data from participants in the adult health examination in Kaohsiung and found the prevalence of CKD to be 28.5%. A prior study showed that the prevalence rate of CKD in Taiwan from 1999-2003 was 9.8% [17], and another reported that the prevalence of CKD among people aged over 20 was 11.9% from 1994-2006 [18]. In another study from Taiwan, people over the age of 40 were screened and a 16.1% prevalence of CKD was found [19], while the prevalence around the world was 10%-14%. The prevalence rates were different in different countries: in India, the prevalence rate was 7.9%; in Singapore, 10.1%; in Thailand, 11.9%; in Norway, 12.7%; and in the US, 11% [20,21]. These rates were all lower than the rate found in the present study. We found the prevalence rate of CKD in stages 3 to 5 to be 16.8%, which was close to the analysis result of 16.1% obtained by Wu et al. in studying 29,345 participants in an adult health examinations in communities of northern Taiwan in 2004-2006 (stage 3 was 15.2%, stage 4 was 0.7%, and stage 5 was 0.2%)(19). In 2010, Wu et al. analyzed the data of 15,817 participants in health examinations in the central part of Taiwan and found the prevalence rate of CKD stage 3 to stage 5 to be 10.7% (stage 3 was 10.2%, stage 4 was 0.3%, and stage 5 was 0.2%), which was lower than the prevalence of CKD in the northern part of Taiwan. Differences in prevalence rates might be related to locality and the age of the subjects [5].

The present study found that males comprised the majority of CKD patients, with a prevalence of 31.8%; the prevalence among females was 25.9%. Related studies also indicated that males had higher prevalence rates of CKD than females [18,19]. In terms of age, those aged over 65 had a prevalence of 46.1%, while those aged 40 to 64 had a prevalence rate of only 17.3%, which was a statistically significant difference. Aging is a pathogenic factor of CKD; the prevalence of CKD is higher in elderly populations, with worse renal functioning [19,22]. Nicotine is considered to be harmful to vascular endothelial cells, producing peroxy radicals and resulting in renal dysfunction. The cumulative effect in CKD patients was found to be higher than that in ordinary people, consequently accelerating the deterioration of renal function [23,24]. The present study analyzed the correlation between smoking and stages in CKD and found that in stages 1 and 2, the ratio of patients that smoked was higher than that of non-smoking patients, but that in stage 3 to stage 5 CKD, the ratio of non-smoking patients was higher than that of smoking patients ($p < .001$). A possible cause might be that with the cross-sectional design of the study, the causal relationship between the smoking habit and cutting down or quitting smoking after contracting CKD could not be determined. Lin (2012) pointed out that patients with stage 4 and 5 CKD had only a 50% to 80% intake of oxygen compared with ordinary people, which seriously influenced the amount of physical activity. The patients were therefore limited to gentle activities and the rate and level of exercise was decreased [25]. The present study also found that CKD patients in stages 4 and 5 had higher rates of “not exercising” than “exercising”.

Subjects with BMI ≥ 27 kg/m² had a higher risk of CKD and different stages of CKD. This result was similar to previous findings, which suggested that the higher the BMI, the more prevalent CKD was, or even the higher the risk of ESRD was [26,27]. Other studies also discovered that obesity resulted in higher GFR and induced adipose cell to produce molecules initiating inflammation. Severe obesity also increased the volume of blood flow in the kidneys, resulting in progressive impairment of renal function [28]. Both CKD

patients and CKD patients in different stages had a high prevalence rate of high triglyceride, but there was no significant difference in cholesterol. This result was similar to that of prior studies, which found that the main dyslipidemia syndrome in CKD patients was high triglyceride, followed by higher levels of LDL-C and lower levels of HDL-C; there was no direct mention of the correlation with cholesterol [18,29]. High blood pressure is a significant factor in CKD. The present study showed that CKD patients had a 34.3% prevalence rate of elevated blood pressure. Many of the kidney diseases are accompanied by elevated blood pressure, which accelerates the deterioration of renal function and increases the risks of cardiovascular complications resulting from CKD. Our study also showed that an increase in blood pressure resulted in a greater chance of developing CKD ($p < .001$); this finding was similar to that of other studies [28,30]. The CKD patients in the present study had a 33.8% rate of hyperglycemia, and patients in stages 3 to 5 had a higher rate of elevated FPG than patients in stages 1 and 2 (20.1% vs. 13.7%). Renal lesions caused by diabetes became the main cause of ESRD. A study on diabetes patients complicated with CKD (stage 5) suggested that patients with diabetes began their hemodialysis treatment earlier than patients without diabetes [31]. The prevalence rate of MetS was 34.6% among CKD patients. Of the risk factors for MetS and its components, except cholesterol, obesity, elevated blood pressure, elevated FPG, and high triglyceride are also risk factors for CKD. The analysis result was statistically significant ($p < .001$), and was similar to the findings of other studies [19,32].

In order to understand the association between the concentration of UA and CKD, the present study categorized patients based on different concentrations of UA and analyzed the data using multiple logistic regression models I, II, and III. The analysis result showed that males had a 1.16-1.18-fold greater chance of developing CKD than females, after adjusting for potential confounding factors. Patients aged 65 and older had a 3.92-3.95 times greater chance of developing CKD than patients aged 40-64, indicating that the older one gets, the greater the risk of developing CKD. Previous studies did not find gender to be a significant factor of CKD [13,19,33], but their findings regarding age as a variable were the same as in the present study, indicating that aging raises the risk of CKD [19,33].

The lifestyle of Taiwanese people is constantly changing, and the lack of vegetable and fruit intake and regular exercise and the consumption of excess calories are causing an increase in obesity and chronic diseases in the population. The present study found that the prevalence rate of CKD in people who ate 3 dishes of vegetables and 2 kinds of fruit daily was 15%-18% lower than that in people who did not have a daily intake of vegetables and fruit. A study of 77,891 participants aged 45-74 found that a daily intake of vegetables and fruit reduced the risk of chronic disease; people who ate 733g of fruit and vegetables per day had a 24% reduced risk of cardiovascular diseases compared to those who ate 186g of fruit and vegetables per day [34]. The increase in intake of vegetables and fruit was a protective factor, delaying the deterioration of renal function. Also, the rate of developing CKD in patients with MetS was 1.21-1.29 times that of patients without MetS. Research has indicated that CKD was relevant to MetS: the more components of MetS one has, the higher the risk of developing CKD [35].

The concentration of UA was shown to be a risk factor for CKD in models I, II, and III. In models II and III, the result showed that the risk of CKD increased with the obvious rise in the concentration of UA. The adjusted ORs were 2.38-6.41 and 1.22-3.82, respectively. Previous studies also had similar findings [7,19,36].

This study has some limitations. First, it was designed as a cross-sectional study; thus,

only a “snapshot” of the association between UA and CKD could be evaluated. Data took the form of prevalence rates only. The analysis was purely correlational, so causal inferences cannot be made. Second, all of our study data came from an adult health examination carried by a single community hospital; therefore, selection bias could not be completely avoided.

In conclusion, the subjects in the present study had a high prevalence of CKD, reaching 28.5%; 45.1% of patients had CKD and a high UA concentration. In different stages of CKD, we found that the abnormality rate of CKD increased along with the increase in the concentration of UA. After controlling other variables, UA was still a risk factor for CKD, and the risk of CKD increased with the increase in the concentration of UA.

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