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Metabolic syndrome and chronic kidney disease in general Chinese adults: Results from the 2007–08 China National Diabetes and Metabolic Disorders Study

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ABSTRACT

Background: China is undergoing a rapid transition to an urbanized and Western diet pattern, which worsens the public health burden of metabolic syndrome (MS) and chronic kidney disease (CKD). We aimed to estimate the prevalence of CKD among adults with MS and to evaluate the association between MS and CKD in China.
Methods: The data were obtained from the China National Diabetes and Metabolic Disorders Study conducted from June 2007 to May 2008. A total of 15,987 individuals aged 20 y or older were included as study participants.
Results: Age-standardized prevalence of CKD, which was defined as a glomerular filtration rate <60 ml/min/1.73 m^2, in participants with and without MS was 4.64% and 3.30%, respectively. The multivariate-adjusted odds ratio of CKD associated with MS was 1.495 (95% CI: 1.190–1.879). Elevated blood pressure, elevated fasting glucose, elevated triglycerides, and reduced high-density lipoprotein cholesterol had statistically significant increased odds ratios of 1.218, 1.256, 1.325 and 1.797 for CKD, respectively, while elevated waist circumference was not significantly associated with an increased odds ratio of CKD.
Conclusions: Our study suggests an increasing prevalence of CKD among Chinese adults with MS and a strong association between CKD and MS.

1. Introduction

China's large population has a high prevalence of chronic kidney disease (CKD) [1,2], which contributes greatly to the increase of cardiovascular disease, end-stage renal disease and kidney transplantation [3]. Metabolic syndrome (MS), which is characterized as a cluster of metabolic abnormalities including obesity, hyperglycemia, hypertension and dyslipidemia [4], shares many risk factors with CKD [5,6]. During the past decade, the association of MS with CKD has been emerging [5]. According to Yi-Jing Sheen's review, the association between MS and CKD in different populations varies with odds ratio (OR) ranging from 0.93 to 2.60 [6]. Of dozens of studies on MS and CKD, an insufficient number involves epidemiologic studies focusing on the Chinese population. To the best our knowledge, there have been less than ten studies to date [7–13], and most of these were regional or involved a single province [7–12]. The most recent nationwide study was reported by Chen, who analyzed the data from the International Collaborative Study of Cardiovascular Disease in Asia (InterASIA) study conducted during 2000 to 2001 [13]. In the past decade, China is undergoing a rapid transition to an urbanized and Western diet pattern, including high-protein food intake [14], which worsens the public health burden of MS and CKD. Therefore, our knowledge needs to be updated.

Given this background, we utilized the data from the 2007–08 China National Diabetes and Metabolic Disorders Study; we aimed to estimate the prevalence of CKD among adults with MS and to evaluate the association between MS and CKD in Chinese adults.

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2. Material and methods

2.1. Study population

The 2007–08 China National Diabetes and Metabolic Disorders Study was a nationwide population-based cross-sectional survey, conducted from June 2007 to May 2008. The details of the study have been described elsewhere [15]. In brief, a multi-stage stratified sampling method was used to select a nationally representative sample of Chinese adults aged >20 y. A total of 17 study group field centers participated in the study, and 54,240 individuals from the general population were selected and invited. Of those individuals, 87.3% (47,325 individuals: 18,976 men and 28,349 women) participated, and 85.2% (46,239 individuals: 18,419 men and 27,820 women) completed the study. Considering kidney function was not the primary expected outcome, serum creatinine (SCr) was not measured at all of the centers. Therefore, we only included 15,987 individuals (6421 men and 9566 women) with complete data on SCr, fasting plasma glucose, systolic blood pressure, diastolic blood pressure, serum triglyceride level, serum high-density lipoprotein cholesterol (HDL-c), and waist circumference. The map of inclusive/exclusive centers is shown in Fig. S1. This study was approved by the institutional review boards from all of the 17 participating centers. Written informed consent was obtained from each participant prior to data collection. The 17 institutional review boards' approvals covered every participant in the study.

2.2. Data collection

A standard questionnaire was designed and administered by trained physicians or nurses to collect information on demographic characteristics, lifestyle risk factors, and personal medical history. Educational level was categorized as college level or above, secondary school, and elementary school or below. Yearly family income was categorized as <10,000 China Yuan (CNY), 10,000–30,000 CNY and >30,000 CNY. Cigarette smoking was defined as a lifetime history of smoking at least 100 cigarettes. Alcohol drinking was defined as consuming alcohol at least once per week for ≥1 y. Physical activity was defined as participating in moderate or vigorous activity for 30 min/day for at least 3 days a week. Body weight and height were measured without shoes and in light clothing. Waist circumference was measured at the middle point between the costal margin and iliac crest. Blood pressure was measured using a standardized mercury sphygmomanometer in the sitting position after at least 5 min of rest; 2 consecutive readings of blood pressure were taken on the same arm and the mean of the 2 measures was used for analysis [15].

After at least 10 h of overnight fasting, an oral glucose tolerance test was performed on all subjects for the measurement of serum glucose and insulin. Participants with no history of diabetes were administered a standard 75-g glucose solution, while participants with a self-reported history of diabetes were given a steamed bun that contained approximately 80 g of complex carbohydrates for safety reasons. Fasting blood samples were also taken to measure serum triglyceride and HDL-c level. All laboratory measurements met a standardization and certification program [15].

2.3. Definition of metabolic syndrome and chronic kidney disease

2.3.1. Metabolic syndrome

Metabolic syndrome was defined using the National Cholesterol Education Program Adult Treatment Panel III (NECP-ATP-III) criteria as ≥3 of the following 5 metabolic components: 1) elevated waist circumference: ≥90 cm (males) or ≥80 cm (females); 2) elevated triglycerides: ≥1.69 mmol/l or the use of lipid medications; 3) elevated blood pressure: systolic blood pressure ≥130 mm Hg, or diastolic blood pressure ≥85 mm Hg, or the use of antihypertensive medications; 4) elevated fasting glucose: ≥5.6 mmol/l or the use of diabetes medications; 5) reduced HDL-c: <1.04 mmol/l (male) or <1.29 mmol/l (female) [4].

2.3.2. Definition of chronic kidney disease

Glomerular filtration rate (GFR) was calculated using the abbreviated equation developed by the modification of diet in renal disease (MDRD) study with modification for the Chinese population [16]. Considering most of our centers measured SCr on a Hitachi analyzer using the Jaffe's kinetic method, we adopted the following equation: $175 \times (\text{SCr} \times 0.01131)\ \ (\text{mmol/l})^{-1.234} \times \text{Age}\ \ (\text{y})^{-0.179} \times (0.79$ if female), which has been validated in the Chinese population and is also used by previous studies [9]. Chronic kidney disease (CKD) was defined as a GFR <60 ml/min/1.73 m^2 according to the US National Kidney Foundation guidelines [17].

2.3.3. Other definitions

Standard World Health Organization criteria were used for the diagnosis of diabetes: fasting glucose ≥7.0 mmol/l or 2 hour postprandial glucose ≥11.1 mmol/l, or self-reported use of diabetes medications [18]. Hypertension was defined according to the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: systolic blood pressure of ≥140 mm Hg, diastolic blood pressure of ≥90 mm Hg, or self-reported use of antihypertensive medications [19].

2.4. Statistical analysis

Data were analyzed using SPSS 18.0 or Stata 11.0 software for Windows. Data were expressed as the mean ± SD, median with interquartile range, or percentage as suitable. Comparisons between groups were analyzed by *t*-test or Mann–Whitney *U*-test for measurement data, and χ^2 test for enumeration data.

Age-standardized prevalence of CKD was compared in populations with and without MS according to gender. Age-standardized point prevalence estimates and standard error (SE) stratified by sex were calculated using Stata (ver. 11.0) *svy* commands (direct standardization) to account for the multi-stage stratified random sampling design. The calculation was weighted based on Chinese population data from 2006 [20]. The crude prevalence of CKD was determined for participants with and without the five individual components of MS, which was also calculated by the number of the MS components.

Logistic regression analysis was utilized to examine the association between MS and its components and CKD. Odds ratios (OR) and 95% confidence intervals (95% CI) were calculated using a forward stepwise method. The covariables in the multivariate analysis were age (continuous variable), gender, ethnics, educational level, yearly family income, cigarette smoking, alcohol drinking, and physical activities. Because hypertension and diabetes are the most important established risk factors for CKD [21], a further adjustment for hypertension and diabetes was performed in the next step. In particular, we calculated the adjusted OR after excluding the individuals with diabetes since diabetes population do much contribution to CKD.

We conducted a sensitivity analysis between study participants and the excluded participants to evaluate the relevance because large amount of individuals dropped out of our analysis. All statistical tests were 2 sided. $P < 0.05$ was considered statistically significant.

3. Results

The clinical characteristics of the study participants are shown in Table 1. Of a total of 15,987 participants, 4749 had MS. On average, participants with MS were older, more likely to be Han, had a relatively low level of education and a high level of yearly family income compared with their participants without MS. The mean level of serum creatinine was significantly higher among the participants with MS compared with those without MS.

Table 1
Demographics, lifestyle risk factors, and clinical characteristics of the study participants with and without metabolic syndrome.

Variable	All participants	Participants with MS	Participants without MS	*P* value
N	15,987	4749	11,238	
Age, y	46.4 ± 13.8	52.6 ± 12.2	43.7 ± 13.7	<0.001
Gender (men), n (%)	6421 (40.2)	1935 (40.7)	4486 (39.9)	NS
Ethnics (Han), n (%)	15,436 (97.7)	4614 (98.3)	10,822 (97.5)	0.003
Educational level, n (%)				<0.001
Elementary school or below	3013 (19.1)	1197 (25.6)	1816 (16.4)	
Secondary school	9497 (60.2)	2815 (60.2)	6682 (60.2)	
College or above	3256 (20.7)	663 (14.2)	2593 (23.4)	
Yearly family income, n (%)	(n = 15,046)	(n = 4492)	(n = 10,554)	0.025
≤10,000 CNY	4936 (32.8)	1402 (31.2)	3534 (33.5)	
10,000–30,000 CNY	6247 (41.5)	1913 (42.6)	4334 (41.1)	
>30,000 CNY	3863 (25.7)	1177 (26.2)	2686 (25.5)	
Cigarette smoking, n (%)	3685 (23.1)	1107 (23.4)	2578 (23.0)	NS
Alcohol drinking, n (%)	3579 (22.5)	1048 (22.2)	2531 (22.6)	NS
Physical activities, n (%)	7430 (46.6)	2330 (49.3)	5100 (45.5)	<0.001
Waist circumference, cm	81.9 ± 11.0	90.5 ± 8.8	78.3 ± 9.8	<0.001
Body mass index, kg/m^2	24.3 ± 3.8	27.1 ± 3.4	23.2 ± 3.3	<0.001
Systolic blood pressure, mm Hg	122.3 ± 19.5	134.7 ± 18.9	117.1 ± 17.2	<0.001
Diastolic blood pressure, mm Hg	77.5 ± 11.2	83.6 ± 11.2	75.0 ± 10.1	<0.001
Serum glucose level, mmol/l	5.4 ± 1.4	6.2 ± 1.9	5.1 ± 1.0	<0.001
Serum triglyceride level, mmol/l	1.6 ± 1.2	2.5 ± 1.5	1.2 ± 0.7	<0.001
Serum HDL-c level, mmol/l	1.4 ± 0.3	1.2 ± 0.3	1.4 ± 0.3	<0.001
Serum creatinine level, μmol/l	72.8 ± 20.1	73.5 ± 21.2	72.1 ± 19.6	0.006
GFR, ml/min per 1.73 m^2	100.5 (80.4–126.8)	99.0 (78.5–124.4)	102.1 (82.7–128.6)	<0.001

Abbreviations: MS, metabolic syndrome; CNY, China Yuan; HDL-c, high-density lipoprotein cholesterol; GFR, glomerular filtration rate.
Formula: GFR: $175 \times (SCr \times 0.01131)\ (mmol/l)^{-1.234} \times Age\ (y)^{-0.179} \times (0.79 \text{ if female})$.

Age-standardized prevalence of CKD in participants with MS was significantly higher for males, females and males and females combined compared with those without MS (4.90% vs. 2.24%, 6.78% vs. 5.78%, and 4.64% vs. 3.30%, respectively, $P < 0.001$). (Table 2) Elevated blood pressure, increased fasting glucose, increased triglycerides, reduced serum HDL-c, and elevated waist circumference were all significantly associated with an increased prevalence of CKD. Furthermore, a significantly graded relationship was shown between the number of components and the corresponding prevalence of CKD (Table 3).

Crude and multivariate-adjusted odds ratios of CKD associated with MS and its components are presented in Table 4. In the multivariate models, elevated blood pressure, elevated fasting glucose, elevated triglycerides level, and reduced HDL-c had a statistically significant increased odds ratios of 1.218, 1.256, 1.325 and 1.797 for CKD, respectively, while elevated waist circumference was not significantly associated with an increased odds ratio of CKD. Participants with 3, 4, and 5 components of MS had 1.489, 1.618, and 2.327 fold significantly increased odds of CKD, respectively, compared with those with 0 components.

Table 2
Age-standardized prevalence of chronic kidney disease in metabolic syndrome according to gender.

Age group, y	All participants		Participants with MS		Participants without MS		*P* value
	n/N	% ± SE	n/N	% ± SE	n/N	% ± SE	
Male							
20–30	4/933	0.4 ± 0.4	2/116	1.7 ± 2.4	2/817	0.2 ± 0.4	
30–40	12/1220	1.0 ± 0.5	7/333	2.1 ± 1.6	5/887	0.6 ± 0.5	
40–50	16/1548	1.0 ± 0.5	7/511	1.4 ± 1.0	9/1037	0.9 ± 0.5	
50–60	44/1423	3.1 ± 0.9	23/491	4.7 ± 1.9	21/932	2.3 ± 1.0	
≥60	82/1297	6.3 ± 1.3	41/484	8.5 ± 2.5	41/813	5.0 ± 1.5	
Crude	158/6421	2.5 ± 0.4	80/1935	4.1 ± 0.9	78/4486	1.7 ± 0.3	
Standardized		3.14 ± 0.49		4.90 ± 1.16		2.24 ± 0.39	<0.001
Female							
20–30	19/1256	1.5 ± 0.7	1/55	1.8 ± 3.7	18/1201	1.5 ± 0.7	
30–40	42/1961	2.1 ± 0.7	5/261	1.9 ± 1.7	37/1700	2.2 ± 0.8	
40–50	74/2393	3.1 ± 0.7	26/589	4.4 ± 1.6	48/1804	2.7 ± 0.7	
50–60	115/2291	5.0 ± 0.9	55/983	5.6 ± 1.4	60/1308	4.6 ± 1.1	
≥60	167/1665	10.0 ± 1.5	96/926	10.4 ± 1.9	71/739	9.6 ± 2.1	
Crude	417/9566	4.4 ± 0.4	183/2814	6.5 ± 0.9	234/6752	3.5 ± 0.4	
Standardized		6.13 ± 0.58		6.78 ± 1.39		5.78 ± 0.75	<0.001
Total							
20–30	23/2189	1.1 ± 0.4	3/171	1.8 ± 1.9	20/2018	1.0 ± 0.4	
30–40	54/3181	1.7 ± 0.4	12/594	2.0 ± 1.2	42/2587	1.6 ± 0.5	
40–50	90/3941	2.3 ± 0.5	33/1100	3.0 ± 1.0	57/2841	2.0 ± 0.5	
50–60	159/3714	4.3 ± 0.6	78/1474	5.3 ± 1.1	81/2240	3.6 ± 0.8	
≥60	249/2962	8.4 ± 1.0	137/1410	9.7 ± 1.6	112/1552	7.2 ± 1.3	
Crude	575/15,987	3.6 ± 0.3	263/4749	5.5 ± 0.7	312/11,238	2.8 ± 0.3	
Standardized		3.77 ± 0.31		4.64 ± 0.70		3.30 ± 0.36	<0.001

Abbreviations: SE, standard error. The calculations were weighted on the basis of Chinese population data from 2006; Chronic kidney disease was defined as a GFR <60 ml/min/1.73 m^2.

Table 3
Crude-prevalence of chronic kidney disease among participants with and without component of metabolic syndrome.

Component	n/N	Prevalence ± SE	*P* value
Raised blood pressure			<0.001
Yes	329/6651	4.9 ± 0.5	
No	246/9336	2.6 ± 0.3	
Raised serum glucose			<0.001
Yes	212/4248	5.0 ± 0.7	
No	363/11,739	3.1 ± 0.3	
Raised serum triglycerides			<0.001
Yes	235/4991	4.7 ± 0.6	
No	340/10,996	3.1 ± 0.3	
Lowered serum HDL-c			<0.001
Yes	267/5179	5.2 ± 0.6	
No	308/10,808	2.8 ± 0.3	
Larger waist circumference			<0.001
Yes	290/6807	4.3 ± 0.4	
No	285/9180	3.1 ± 0.4	
Number of components			<0.001
0	70/3699	1.9 ± 0.4	
1	114/4053	2.8 ± 0.5	
2	128/3486	3.7 ± 0.6	
3	131/2663	4.9 ± 0.8	
4	90/1568	5.7 ± 0.8	
5	42/518	8.1 ± 2.4	

Abbreviations: HDL-c, high-density lipoprotein cholesterol; SE, standard error. Chronic kidney disease was defined as a GFR <60 ml/min/1.73 m^2.

The crude odds ratio of CKD for MS was 2.019 (95% CI: 1.626–2.507). After adjustments for age, gender, ethnics, educational level, yearly family income, cigarette smoking, alcohol drinking, and physical activities, the odds ratio was 1.495 (95% CI: 1.190–1.879). After further adjustment for hypertension and diabetes, significance still persisted with an odds ratio of 1.462 (95% CI: 1.147–1.864). Additionally, among participants without diabetes the same significant association between MS and CKD was observed (OR: 1.321, 95% CI: 1.075–1.622).

Table S1 shows the comparison of the clinical characteristics between study and drop-out participants to evaluate the relevance. The results showed no significant difference with the proportion of gender, waist circumference, systolic blood pressure, or serum glucose. However, the study participants were older compared with the drop-out participants, and there were significant differences with other metabolic variables including body mass index, diastolic blood pressure, serum triglyceride level and serum HDL-c level.

4. Discussion

Since a report on the data from the InterASIA study [13], there were no new nationwide reports that evaluated the association between MS and CKD in China. The present paper, utilizing the data from the 2007–08 China National Diabetes and Metabolic Disorders Study, estimated an increasing age-standardized prevalence of CKD (4.64%), defined as a GFR <60 ml/min/1.73 m^2, in the MS population. The results also showed that Chinese adults with MS had a 50% increase in the odds of CKD compared with individuals without MS.

In the present study, the age-standardized prevalence of CKD in participants with MS was 4.64%, which was higher than that in another nationwide report (3.3%) on the data from the InterASIA study [13]. Some possibilities may contribute to the difference, including the age of the participants, the parameters of HDL-c in the MS criteria, and the different equation used to calculate estimated GFR. Apart from the above explanations, we speculated that the prevalence of CKD in participants with MS was increasing over the past decade in China due to the increasing incidence of obesity and type 2 diabetes coupled with an aging population [3].

This study showed that MS was significantly associated with CKD and that Chinese adults with MS had a 50% increased odds of CKD compared with individuals without MS. Diabetes and hypertension are the most important well-established risk factors for CKD [21]. In the multivariable analysis, we further adjusted for diabetes and hypertension and found that significance still persisted with an odds ratio of 1.462 (95% CI: 1.147–1.864), indicating that the association between MS and CKD was independent of diabetes and hypertension. Several epidemiological studies have documented a relationship between MS and CKD [7–9,11–13,22–37]. For example, Chen et al. analyzed data from the Third National Health and Nutrition Examination Survey and showed that MS might be an important factor in the etiology of CKD [37]. Kurella et al. followed a total of 10,096 nondiabetic participants for 9 y and found that MS was independently associated with an increased risk for CKD in nondiabetic adults [36]. In China, Chen et al. reported the multivariate-adjusted OR of CKD in participants with MS compared to those without was 1.64 (95% CI: 1.16–2.32) by using the data from the InterASIA study during 2000–2001 [13]. Zhang et al. performed a cross-sectional survey that included 2310 participants (age ≥ 40 y) from Beijing in 2004 and observed strong unadjusted and adjusted associations between MS and CKD [11]. All of the above studies consistent with our study confirmed a strong relationship between MS and CKD.

Table 4
Crude and multivariate-adjusted odds ratio of chronic kidney disease associated with metabolic syndrome and its components.

Variable	Odds ratio of chronic kidney disease (95% CI)					
	Crude[a]	x^2	*P* value	Multivariate-adjusted[b]	x^2	*P* value
Elevated blood pressure	1.934 (1.625–2.302)	55.085	<0.001	1.218 (1.005–1.474)	4.061	0.044
Increased fasting glucose	1.686 (1.410–2.017)	37.764	<0.001	1.256 (1.043–1.512)	5.806	0.016
Increased triglycerides	1.555 (1.305–1.854)	34.706	<0.001	1.325 (1.106–1.586)	9.367	0.002
Reduced HDL-c	1.918 (1.614–2.281)	54.480	<0.001	1.797 (1.504–2.146)	41.693	<0.001
Elevated waist circumference	1.370 (1.153–1.628)	12.803	<0.001	0.856 (0.713–1.029)	2.740	NS
Number of component[c]						
1	1.525 (1.117–2.082)	7.061	0.008	1.176 (0.857–1.613)	1.008	NS
2	1.912 (1.405–2.600)	17.043	<0.001	1.209 (0.880–1.660)	1.367	NS
3	2.629 (1.935–3.572)	38.217	<0.001	1.489 (1.080–2.053)	5.918	0.015
4	3.203 (2.307–4.447)	69.716	<0.001	1.618 (1.145–2.286)	7.444	0.006
5	4.977 (3.334–7.432)	61.572	<0.001	2.327 (1.530–2.599)	15.583	<0.001
Metabolic syndrome						
Model 1 (n = 15987)	2.019 (1.626–2.507)	40.489	<0.001	1.495 (1.190–1.879)	13.935	<0.001
Model 2[d] (n = 15987)				1.462 (1.147–1.864)	9.387	0.002
Model 3[e] (n = 14297)				1.321 (1.075–1.622)	7.026	0.008

[a] Unadjusted.
[b] Adjusted for age (continuous variable), gender, ethnics, educational level, yearly family income, cigarette smoking, alcohol drinking, and physical activities.
[c] Number zero of component as ref.
[d] Further adjusted for hypertension and diabetes.
[e] Individuals with diabetes excluded.

The relationship between individual components of MS and CKD in the Chinese population is inconclusive. In our study, multivariate-adjusted analysis showed that elevated waist circumference was not significantly associated with CKD (OR: 0.856, 95% CI: 0.713–1.029, $P = 0.098$), which was consistent with the findings from Zhang et al. [11] and Jiang et al. [9] but opposite to the results from the report by Chen et al. [13]. The remaining four individual components were independent risk factors for CKD in our study, but Chen et al. [13] reported that elevated blood pressure, elevated triglycerides, and reduced HDL-c were not significantly associated with CKD. Similarly, reduced HDL-c in Zhang's study [11], increased serum triglycerides concentration in the Jiang et al. [9] and Liu et al. [38] studies, and reduced HDL-c in the Jiang et al. study [9] were not significant determinants of CKD. The discrepancy might be partly due to differences in the definitions used for MS, the equation used to calculate estimated GFR, and the demographic characteristics of the included study participants. For example, Chen et al. [13] included participants aged 35–70 y and used an original equation for estimated GFR. Zhang et al. [11] examined an elder population with age >40 y and Jiang et al. [9] studied the association between MS and CKD in a rural Chinese population. Liu et al. [38] recruited participants aged >45 y and the cutoff of hypertriglyceridemia was 2.26 mmol/l. However, similar to the other three studies, we identified a graded relationship between the number of components and the corresponding prevalence of CKD.

Although the 2007–08 China National Diabetes and Metabolic Disorders Study was a well-designed population-based survey, some limitations should be mentioned. Firstly, the association in the present paper, as with any observational study, did not imply certain causality. Secondly, GFR was not directly measured but instead was calculated with an estimated creatinine-based equation. However, the following two reasons may offset the bias to some extent: (a) these methodologies are complex and not feasible in a large population-based epidemiologic study; (b) the modified MDRD equation we adopted shows lower bias and higher accuracy in each stage of CKD when applied to Chinese populations, particularly in patients with near-normal kidney function [16]. Finally, a large number of participants without serum creatinine measurement were excluded. Because these individuals showed significant difference in age, ethnicity and some metabolic variables based on the sensitivity analysis shown in Table S1, exclusion of these individuals would be expected to bias the study results toward the null.

In summary, the present paper, which used a nationwide representative sample, estimates an increasing prevalence of CKD in Chinese adults with MS. The results also indicate a strong association between CKD and MS. With the increasing number of patients with MS in China [39], the burden of CKD needs more effective control and prevention strategies.

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.cca.2014.01.004.

Abbreviations

CKD chronic kidney disease
MS metabolic syndrome
InterASIA international collaborative study of cardiovascular disease in ASIA
SCr serum creatinine
CNY China Yuan
NECP-ATP-III National Cholesterol Education Program Adult Treatment Panel III
MDRD modification of diet in renal disease

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