Original Article

Relationship between Blood Pressure and Chronic Kidney Disease in the Japanese Population: The Lower the Better Even in Individuals without Hypertension?

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In hypertensive subjects, it has been demonstrated that the lower the blood pressure, the lower the incidence of chronic kidney disease (CKD). However, whether this relationship holds true in individuals without hypertension—that is, in individuals with a blood pressure <140/90 mmHg—remains unknown. This study was performed to assess the relationship between blood pressure and CKD in a Japanese population without hypertension. Among 13,007 Japanese participants in a general health screening, 9,596 (5,691 men and 3,905 women) were found to have either normal blood pressure or prehypertension, and were enrolled in this study. We categorized these individuals' blood pressure into six classes: BP-C1, <90/<65 mmHg; BP-C2, 90–100/65–70 mmHg; BP-C3, 100–110/70–75 mmHg; BP-C4, 110–120/75–80 mmHg; BP-C5, 120–130/80–85 mmHg; and BP-C6, 130–140/85–90 mmHg. Albuminuria was defined as a urinary albumin excretion ratio of ≥ 30 mg/g. Low estimated glomerular filtration rate (eGFR) was defined as eGFR <60 mL/min/1.73 m². In men, when BP-C3 was used as a reference, multivariate logistic regression analysis adjusted for age, body mass index, serum lipid profiles, fasting plasma glucose and smoking status showed that BP-C1, BP-C2, BP-C4, BP-C5 and BP-C6 were associated with albuminuria with an adjusted odds ratio of 1.85 (0.53–6.46), 1.22 (0.59–2.51), 1.62 (1.01–2.59), 2.57 (1.64–4.02), and 3.81 (2.44–5.96). In women, the adjusted odds ratios of the risk for albuminuria in BP-C2, BP-C3, BP-C4, BP-C5 and BP-C6, as compared with BP-C1 as a reference, were 1.83 (0.70–4.79), 2.13 (0.84–5.42), 2.80 (1.10–7.14), 2.59 (0.99–6.78), and 3.99 (1.50–10.64). Blood pressure was not significantly associated with low eGFR in either gender. The risk for albuminuria was significantly greater when blood pressure exceeded 110/75 mmHg in both genders. (*Hypertens Res* 2008; 31: 213–219)

Key Words: blood pressure, chronic kidney disease, Japanese population

Introduction

The increasing prevalence of end-stage renal disease (ESRD) that may require hemodialysis is now a worldwide public health problem because of poor outcomes and high costs. To

prevent an increase in the number of ESRD patients, intensive intervention at an early stage of kidney impairment has recently been emphasized. This enthusiasm has led to the establishment of the concept of chronic kidney disease (CKD). According to the National Kidney Foundation (NKF) Kidney Disease Outcomes Quality Initiative (K/DOQI) crite-

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Table 1. Characteristics of the Enrolled Male Subjects According to Blood Pressure Levels

	Total (<i>n</i> =5,691)	BP-C1 (<i>n</i> =67)	BP-C2 (<i>n</i> =401)	BP-C3 (<i>n</i> =1,130)	BP-C4 (<i>n</i> =1,565)	BP-C5 (<i>n</i> =1,140)	BP-C6 (<i>n</i> =1,088)	<i>p</i> value
Age, years old	52.2±10.5	53.4±11.9	51.0±10.8	50.8±10.6	51.3±10.5	53.2±10.4	54.2±11.9	<0.0001
BMI, kg/m ²	23.3±2.7	20.9±2.1	21.8±2.2	22.5±2.3	23.1±2.5	23.8±2.7	24.3±2.9	<0.0001
Systolic BP, mmHg	116.3±11.9	85.5±3.5	95.6±3.0	104.9±3.0	114.0±3.2	123.0±3.9	132.2±4.7	<0.0001
Diastolic BP, mmHg	74.3±7.9	56.4±4.0	62.5±4.3	67.6±4.1	72.8±4.3	78.3±4.3	83.6±4.5	<0.0001
TC, mg/dL	206.7±32.2	208.2±32.9	200.0±31.3	202.8±32.6	206.9±32.1	208.4±31.9	210.3±31.9	<0.0001
HDL-C, mg/dL	55.0±13.4	60.4±16.5	55.0±13.4	55.2±12.9	55.2±13.9	54.8±13.0	54.7±13.6	0.032
LDL-C, mg/dL	127.2±30.6	125.3±38.2	123.8±30.5	125.4±30.6	127.6±30.3	127.5±30.9	129.2±29.9	0.017
TG, mg/dL	128.0±88.7	108.9±96.1	106.9±58.2	113.8±73.6	127.5±97.0	136.7±96.9	140.6±84.4	<0.0001
Hyperglycemia, <i>n</i> (%)	698 (12.3%)	6 (9.0%)	30 (7.5%)	78 (6.9%)	175 (11.2%)	212 (14.7%)	197 (18.1%)	<0.0001
Fasting plasma glucose, mg/dL	98.1±19.3	96.6±24.2	94.2±16.9	94.9±15.5	97.6±19.2	99.4±17.7	102.2±24.0	<0.0001
HbA1c, %	5.34±0.72	5.43±0.91	5.28±0.68	5.26±0.62	5.33±0.69	5.36±0.68	5.44±0.86	<0.0001
Smoking status								<0.0001
Former smoking, <i>n</i> (%)	1,849 (32.5%)	17 (25.4%)	95 (23.7%)	316 (28.0%)	496 (31.7%)	496 (34.4%)	429 (39.4%)	
Current smoking, <i>n</i> (%)	1,893 (33.3%)	32 (47.8%)	183 (45.6%)	402 (35.6%)	522 (33.4%)	440 (30.6%)	314 (28.9%)	
UAER, mg/g	14.1±73.7	9.1±22.0	11.1±72.4	8.0±33.5	11.5±50.3	19.8±117.8	18.0±56.3	0.0005
Albuminuria, <i>n</i> (%)	331 (5.8%)	3 (4.5%)	11 (2.7%)	26 (2.3%)	65 (4.2%)	102 (7.1%)	124 (11.4%)	<0.0001
eGFR, mL/min/1.73 m ²	70.7±9.9	71.5±11.3	71.3±9.9	71.3±9.8	70.8±9.6	70.5±10.0	70.1±9.9	0.055
Low eGFR, <i>n</i> (%)	735 (12.9%)	9 (13.4%)	42 (10.5%)	131 (11.6%)	189 (12.1%)	206 (14.3%)	158 (14.5%)	0.078

BMI, body mass index; BP, blood pressure; eGFR, estimated glomerular filtration rate; HbA1c, hemoglobin A1c; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TC, total cholesterol; TG, triglyceride; UAER, urinary albumin excretion ratio.

ria, CKD is defined as an estimated glomerular filtration rate (eGFR) of <60 mL/min/1.73 m² and/or kidney damage identified mainly by microalbuminuria (1).

Hypertension is a well-known risk factor for the progression of renal and cardiovascular diseases (2–5). Previous studies have demonstrated that lower blood pressure leads to better clinical outcomes in regard to renal and cardiovascular diseases (2, 6–10), thereby providing the academic basis of “the lower the better” strategy in daily practice. Only a few studies, however, have evaluated the relationship between blood pressure and CKD in the non-hypertensive range of blood pressure. Haroun *et al.* (10) demonstrated that a blood pressure of 130–140/85–90 mmHg was associated with an increase in serum creatinine levels in a predominantly Caucasian population. Ramirez *et al.* (4) showed that the risk for proteinuria was significantly increased at a systolic blood pressure of 130–140 mmHg in a Chinese population, whereas a significant increase in the risk for proteinuria was not found at a blood pressure level below 140/90 mmHg in a Malaysian population.

In the current study, we sought to assess the relationship between blood pressure level and CKD in Japanese individuals without hypertension. We used albuminuria and low eGFR as indicators of CKD, and the two indicators were evaluated separately so that the pathophysiology of kidney damage could be clearly assessed.

Methods

Study Subjects

The study was approved by the Ethical Committee of Mitsui Memorial Hospital. Between April 2005 and August 2006, 13,007 subjects (8,298 men, 4,709 women) underwent a general health screening. Among these subjects, 9,596 subjects (5,691 men, 3,905 women) who had blood pressure <140/90 mmHg and were not taking any antihypertensive medication were enrolled in this study. In Japan, regular health check-ups for employees are legally mandated, and thus, most of these subjects did not have serious health problems.

Body mass index (BMI) was calculated as body weight (kg) divided by the square of the height (m²). Smoking habits were self-reported by means of a questionnaire, and subjects were classified as non-smokers, former smokers or current smokers. Subjects were judged to be former smokers if they had stopped smoking at least 1 month before the health evaluation.

Laboratory Analysis

Blood samples were taken from the subjects after an overnight fast. Serum levels of total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C) and triglycerides (TG) were determined

Table 2. Characteristics of the Enrolled Female Subjects According to Blood Pressure Levels

	Total (n=3,905)	BP-C1 (n=182)	BP-C2 (n=645)	BP-C3 (n=1,095)	BP-C4 (n=962)	BP-C5 (n=636)	BP-C6 (n=385)	p value
Age, years old	50.7±10.5	46.9±10.3	47.2±10.5	49.2±9.8	51.2±10.3	53.9±10.1	56.3±10.3	<0.0001
BMI, kg/m ²	20.8±2.7	19.2±2.2	19.7±2.1	20.4±2.3	21.1±2.6	21.8±2.8	22.3±2.9	<0.0001
Systolic BP, mmHg	110.3±13.0	85.6±3.7	95.1±2.8	104.5±2.9	113.9±3.1	123.5±3.6	133.1±4.1	<0.0001
Diastolic BP, mmHg	68.9±8.8	55.0±4.8	60.3±4.8	65.5±4.9	71.1±5.0	76.7±5.2	81.7±5.9	<0.0001
TC, mg/dL	212.1±35.5	201.6±31.8	205.3±35.4	209.3±35.8	212.8±35.3	219.1±34.0	223.5±34.5	<0.0001
HDL-C, mg/dL	68.0±14.4	69.1±13.4	69.0±14.0	68.6±14.4	67.9±14.5	66.9±14.1	66.4±15.3	0.014
LDL-C, mg/dL	123.4±32.7	113.5±27.4	117.0±32.0	120.4±32.0	124.2±32.7	130.1±32.4	134.1±33.2	<0.0001
TG, mg/dL	80.5±43.2	65.3±31.4	69.4±32.9	77.1±41.2	82.3±45.0	90.1±43.6	96.0±53.6	<0.0001
Hyperglycemia, n (%)	129 (3.3%)	0 (0%)	5 (0.8%)	25 (2.3%)	31 (3.2%)	38 (6.0%)	30 (7.8%)	<0.0001
Fasting plasma glucose, mg/dL	89.4±12.5	85.2±7.7	86.6±9.2	88.4±10.5	89.6±12.8	92.6±14.7	92.9±16.8	<0.0001
HbA1c, %	5.11±0.50	5.02±0.41	5.03±0.41	5.07±0.47	5.13±0.49	5.20±0.54	5.20±0.61	<0.0001
Smoking status								<0.0001
Former smoking, n (%)	230 (5.9%)	10 (5.5%)	40 (6.2%)	71 (6.5%)	53 (5.5%)	36 (5.7%)	20 (5.2%)	
Current smoking, n (%)	369 (9.4%)	33 (18.1%)	81 (12.6%)	110 (10.0%)	90 (9.4%)	39 (6.1%)	16 (4.2%)	
UAER, mg/g	13.9±46.1	8.1±7.1	10.7±19.5	14.0±58.6	14.2±39.9	13.0±20.2	22.1±80.0	0.0027
Albuminuria, n (%)	234 (6.0%)	5 (2.7%)	30 (4.7%)	58 (5.3%)	65 (6.8%)	40 (6.3%)	36 (9.4%)	0.0095
eGFR, mL/min/1.73 m ²	69.5±9.8	70.3±9.7	70.3±9.7	69.7±10.0	69.5±9.8	68.9±9.7	67.9±9.7	0.0025
Low eGFR, n (%)	592 (15.2%)	22 (12.1%)	85 (13.2%)	150 (13.7%)	143 (14.9%)	111 (17.5%)	81 (21.0%)	0.0028

BMI, body mass index; BP, blood pressure; eGFR, estimated glomerular filtration rate; HbA1c, hemoglobin A1c; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TC, total cholesterol; TG, triglyceride; UAER, urinary albumin excretion ratio.

enzymatically. Plasma glucose was measured by the hexokinase method, and hemoglobin A1c was determined using the latex agglutination immunoassay. The serum creatinine level was determined by the enzymatic method.

Serum creatinine was calibrated by the following formula: calibrated serum creatinine = 0.2 + serum creatinine (enzyme method). Glomerular filtration rate (GFR) was estimated by the abbreviated Modification of Diet in Renal Disease (MDRD) equation as follows (1):

$$\text{eGFR (mL/min/1.73 m}^2\text{)} = 186.3 \times (\text{calibrated serum creatinine})^{-1.154} \times (\text{age})^{-0.203} \times 0.881$$

(× 0.742, if female).

In the MDRD formula, 0.881 is the coefficient of Japanese for an eGFR specific to the Japanese population, as recommended by the Japanese Society of Nephrology (11). The urinary albumin excretion ratio (UAER) was calculated as urinary albumin (mg) per urinary creatinine (g).

Hyperglycemia was defined as fasting plasma glucose (FPG) ≥110 mg/dL and/or treatment with hypoglycemic agents. Albuminuria was defined as UAER ≥30 mg/g, and low eGFR was defined as eGFR <60 mL/min/1.73 m².

Classification of Blood Pressure Levels

Blood pressure level was classified into six categories as follows: BP-C1, systolic blood pressure (SBP) <90 mmHg and diastolic blood pressure (DBP) <65 mmHg; BP-C2, SBP 90–

100 mmHg and/or DBP 65–70 mmHg; BP-C3, SBP 100–110 mmHg and/or DBP 70–75 mmHg; BP-C4, SBP 110–120 mmHg and/or DBP 75–80 mmHg; BP-C5, SBP 120–130 mmHg and/or DBP 80–85 mmHg; BP-C6, SBP 130–140 mmHg and/or DBP 85–90 mmHg.

Statistical Analysis

Continuous variables are expressed as the means±SD. Discrete variables are presented as numbers and percentages. Statistical differences in the means among groups were analyzed by one-way analysis of variance (ANOVA). Frequencies were compared by using the χ^2 test. A multivariate logistic regression model was used to examine the relationship between blood pressure level and the prevalence of albuminuria and low eGFR after adjustment for age, BMI, LDL-C, HDL-C, TG, FPG level and smoking status. A *p* value of less than 0.05 was taken to indicate statistical significance. Statistical analyses were performed with Stat View software version 5.0 (SAS Institute, Cary, USA).

Results

Characteristics of the Enrolled Subjects

Characteristics of the enrolled male and female subjects are shown in Tables 1 and 2, respectively. Albuminuria was found in 331 (5.8%) men and in 234 (6.0%) women. Low

Table 3. Logistic Regression Analysis of the Association between Blood Pressure and Prevalence of Albuminuria in Individuals without Hypertension

	Univariate analysis			Multivariate analysis		
	OR	95% CI	<i>p</i> value	OR	95% CI	<i>p</i> value
Male						
BP-C1	1.99	0.59–6.75	0.27	1.85	0.53–6.46	0.33
BP-C2	1.20	0.59–2.45	0.62	1.22	0.59–2.51	0.60
BP-C3	1.00	—	—	1.00	—	—
BP-C4	1.84	1.16–2.92	0.0096	1.62	1.01–2.59	0.044
BP-C5	3.24	2.09–5.02	<0.0001	2.57	1.64–4.02	<0.0001
BP-C6	5.46	3.55–8.41	<0.0001	3.81	2.44–5.96	<0.0001
Female						
BP-C1	1.00	—	—	1.00	—	—
BP-C2	1.72	0.66–4.52	0.27	1.83	0.70–4.79	0.22
BP-C3	1.98	0.78–5.01	0.15	2.13	0.84–5.42	0.11
BP-C4	2.57	1.02–6.46	0.046	2.80	1.10–7.14	0.03
BP-C5	2.38	0.92–6.11	0.073	2.59	0.99–6.78	0.053
BP-C6	3.65	1.41–9.47	0.0077	3.99	1.50–10.64	0.0056

CI, confidence interval; OR, odds ratio. BP-C1, <90/<65 mmHg; BP-C2, 90–100/65–70 mmHg; BP-C3, 100–110/70–75 mmHg; BP-C4, 110–120/75–80 mmHg; BP-C5, 120–130/80–85 mmHg; BP-C6, 130–140/85–90 mmHg.

eGFR was observed in 735 (12.9%) men and in 592 (15.2%) women. In men, about two-thirds of subjects were either current or former smokers, whereas in women, only about 15% of subjects were either current or former smokers. BMI and the prevalence of hyperglycemia were higher in men than in women.

In men, BMI was larger and HDL-C level was lower when blood pressure level was high. TC, LDL-C, TG and fasting plasma glucose levels were the lowest in the BP-C2 group, and hemoglobin A1c level and the prevalence of hyperglycemia were the lowest in the BP-C3 group. There was a tendency for these parameters to increase as the blood pressure increased above these blood pressure levels. In women, BMI, glucose and lipid profile got worse when the blood pressure level increased.

Impact of Blood Pressure Level on the Prevalence of Albuminuria

The prevalence of albuminuria according to blood pressure levels in both genders is shown in Tables 1 and 2. In men, the prevalence of albuminuria showed a J-shaped relationship, whereas in women the prevalence of albuminuria showed an almost graded increase according to blood pressure level.

Next, multivariate logistic regression analysis adjusted for age, BMI, LDL-C, HDL-C, TG, FPG level and smoking status was performed and the results are shown in Table 3. In men, when BP-C3, the category with the lowest prevalence of albuminuria, was used as a reference, a significant graded increase in the risk for albuminuria was found in BP-C4, BP-C5, and BP-C6. In women, when BP-C1 was used as a reference, the increase in the risk for albuminuria was significant

in both BP-C4 and BP-C6, and borderline significant in BP-C5.

Impact of Blood Pressure Level on the Prevalence of Low eGFR

The eGFR value according to blood pressure levels is shown in Tables 1 and 2. Female subjects with low blood pressure had a slightly higher eGFR than those with high blood pressure. The same tendency was found in men, although the differences among each category were not found to be statistically significant.

The prevalence of low eGFR according to blood pressure levels is also shown in Tables 1 and 2. In men, a J-shaped relationship was found between blood pressure and the prevalence of low eGFR, whereas in women a positive graded association was observed.

The results of multivariate logistic regression analysis adjusted for age, BMI, LDL-C, HDL-C, TG, FPG level and smoking status are shown in Table 4. The reference categories were BP-C2 in men and BP-C1 in women; these were the categories of the lowest prevalence of low eGFR in men and women. The risk for low eGFR did not significantly differ in non-hypertensive individuals of either gender.

Discussion

In the present study, we demonstrated that, in both men and women, the risk for albuminuria was significantly greater when blood pressure exceeded 110/75 mmHg in a Japanese population without hypertension. On the other hand, the risk for albuminuria did not significantly differ in individuals with

Table 4. Logistic Regression Analysis of the Association between Blood Pressure and Prevalence of Low eGFR in Individuals without Hypertension

	Univariate analysis			Multivariate analysis		
	OR	95% CI	p value	OR	95% CI	p value
Male						
BP-C1	1.33	0.61–2.87	0.47	1.19	0.53–2.69	0.68
BP-C2	1.00	—	—	1.00	—	—
BP-C3	1.12	0.78–1.62	0.54	1.07	0.73–1.58	0.72
BP-C4	1.17	0.82–1.67	0.37	1.04	0.71–1.51	0.84
BP-C5	1.43	1.00–2.03	0.048	1.10	0.75–1.60	0.64
BP-C6	1.45	1.01–2.08	0.043	1.04	0.70–1.54	0.84
Female						
BP-C1	1.00	—	—	1.00	—	—
BP-C2	1.10	0.67–1.82	0.7	1.05	0.62–1.79	0.86
BP-C3	1.15	0.72–1.86	0.56	0.94	0.57–1.56	0.81
BP-C4	1.27	0.79–2.05	0.33	0.84	0.50–1.40	0.50
BP-C5	1.54	0.94–2.51	0.086	0.82	0.48–1.39	0.45
BP-C6	1.94	1.17–3.22	0.011	0.83	0.48–1.46	0.52

eGFR, estimated glomerular filtration rate; CI, confidence interval; OR, odds ratio. BP-C1, <90/<65 mmHg; BP-C2, 90–100/65–70 mmHg; BP-C3, 100–110/70–75 mmHg; BP-C4, 110–120/75–80 mmHg; BP-C5, 120–130/80–85 mmHg; BP-C6, 130–140/85–90 mmHg.

blood pressure lower than 100–110/70–75 mmHg. On the other hand, such type of association was not present between blood pressure and the risk for low eGFR in our study population.

Hypertension has been shown to be a risk factor for kidney dysfunction as well as cardiovascular diseases (2–5). Previous studies have established that, in hypertensives, the lower the blood pressure level, the better the clinical outcomes in regard to cardiovascular diseases and kidney dysfunction (2, 6–10). However, the relationship between blood pressure and renal function in apparently healthy Japanese with normal blood pressure or prehypertension has not been fully evaluated. Accordingly, this study was performed to determine whether any intervention is needed to regulate blood pressure in this population.

In the present study, a blood pressure level of $\geq 110/75$ mmHg increased the prevalence of albuminuria in both men and women. Because albuminuria has been shown to be associated with the development of cardiovascular events and deaths (12, 13), and because albuminuria is in itself a risk factor for the progression of kidney dysfunction (14), the current study suggests that reduction of blood pressure to below 110/75 mmHg might help to prevent atherosclerotic diseases in the Japanese population. This threshold is nearly the same as that shown in the meta-analysis by Lewington *et al.*, in which a “the lower the better” relationship was found between blood pressure and cardiovascular mortality in individuals with blood pressure above 115/75 mmHg (6). In the Japanese population, Tozawa *et al.* (15) demonstrated that the incidence of ESRD was the lowest in the group with blood pressure below 120/80 mmHg, and it increased along with increases in blood

pressure, which may support our present findings.

Furthermore, in both genders in the present study, there was no significant difference in the risk for albuminuria among the different blood pressure categories below 110/75 mmHg after multivariate adjustment. Therefore, when individuals have blood pressure less than 110/75 mmHg, they may not be considered to be at either higher or lower risk for albuminuria or CKD.

We found that the pattern of the relationship between BMI, glucose or lipid profile and blood pressure level showed a similar tendency to that between the prevalence of albuminuria and blood pressure level in both genders. This finding suggests that lifestyle intervention may help in realizing an optimal blood pressure level in apparently healthy Japanese subjects without hypertension.

Interestingly, the pattern of the relationship between blood pressure classes and prevalence of albuminuria seemed to differ slightly between the genders. The risk for albuminuria showed a more abrupt increase in proportion to a blood pressure level above 110/75 mmHg in men than in women. This variation might result from differences in the concentration of sex hormones between men and women. Androgen has been shown to stimulate the renin-angiotensin-aldosterone system (RAAS) and to increase the sensitivity to angiotensin-II through modulation of angiotensin-II receptors (16). Therefore, baseline RAAS activity may be higher in men than in women. Because angiotensin-II increases the resistance of mainly efferent arterioles, intraglomerular pressure may be higher in men than in women, even in individuals with the same blood pressure level, and may be more susceptible in men than in women to changes in systemic blood pressure *via*

afferent arterioles. In addition, because aldosterone has been shown to have an adverse effect on the kidneys through inflammatory response and fibrosis as well as on the heart (17–21), blood pressure may have a synergic effect on kidney impairment in men.

In this study population, the absolute percentage of the prevalence of albuminuria was slightly higher in women than in men even though the prevalence of hyperglycemia and smoking, the established risk factors for proteinuria, was higher in men than in women (3, 22). This might be because UAER was used as an indicator of albuminuria. Because men tend to have higher skeletal muscle mass than women, the use of UAER might have underestimated the prevalence of albuminuria in men or overestimated it in women, as has been shown in previous studies (23–25).

In the current study, we found that blood pressure was significantly associated with albuminuria, but not with low eGFR, in both genders who did not have hypertension. It should be kept in mind, however, that the duration for which an individual maintains a higher blood pressure level may be an important predictor of GFR because blood pressure level has been shown to be associated with rate of decline of eGFR (26). Longitudinal observations will be needed, therefore, to further assess the relationship between blood pressure and low eGFR.

Limitations

Our study does have some limitations. First, there may have been some selection bias in terms of the subjects who underwent health check-ups. In Japan, however, regular health check-ups for employees are legally mandated, rather than being due to the decision or recommendation of a physician. Second, as we measured only office blood pressure, masked hypertension could not be detected. Therefore, subjects with masked hypertension might have been enrolled in this study, which could have affected the results. Third, owing to the cross-sectional nature of the current study, we are not able to draw conclusions in regard to a causal relationship between blood pressure and kidney impairment. Longitudinal observations will thus be needed. Fourth, ethnic factors for the Japanese population are not well established when using the abbreviated MDRD formula. Therefore, the eGFR value calculated by the MDRD formula may be inappropriate.

Conclusions

In the present study, we found that blood pressure below 110/75 mmHg was the optimal blood pressure for kidney function in a generally healthy Japanese population. Even individuals without hypertension should be encouraged to lower their blood pressure to this level by lifestyle intervention.

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