Use of the Albumin/Creatinine Ratio to Detect Microalbuminuria: Implications of Sex and Race

HOLLY J. MATTIX,* CHI-YUAN HSU,† SHIMON SHAYKEVICH,‡ and GARY CURHAN§‡

**Renal Unit, Department of Medicine, Massachusetts General Hospital, Boston, Massachusetts; †Division of Nephrology, University of California, San Francisco, California; and ‡Department of Medicine and §Channing Laboratory, Brigham and Women's Hospital, Boston, Massachusetts.*

Abstract. The recommended albumin (μg)/creatinine (mg) ratio (ACR) (30 μg/mg) to detect microalbuminuria does not account for sex or racial differences in creatinine excretion. In a nationally representative sample of subjects, the distribution of urine albumin and creatinine concentrations was examined by using one ACR value ($\geq$30 μg/mg) and sex-specific cutpoints ($\geq$17 μg/mg in men and $\geq$25 μg/mg in women) measured in spot urine specimens. Mean urine albumin concentrations were not significantly different between men and women, but urine creatinine concentrations were significantly higher ($P < 0.0001$). Compared with non-Hispanic whites, urine creatinine concentrations were significantly higher in non-Hispanic blacks (NHB) and Mexican Americans, whereas urine albumin concentrations were significantly higher in NHB ($P < 0.0001$) but not Mexican Americans. When a single ACR is used, the prevalence of microalbuminuria was significantly lower among the men compared with women (6.0 *versus* 9.2%; $P < 0.0001$) and among non-Hispanic whites compared with NHB (7.2 *versus* 10.2%; $P < 0.0001$). No significant difference in the prevalence of microalbuminuria between men and women was noted when sex-specific ACR cutpoints were used. In the multivariate adjusted model, female sex (odds ratio, 1.62; 95% confidence interval, 1.29 to 2.05) and NHB race/ethnicity (odds ratio, 1.34; 95% confidence interval, 1.12 to 1.61) were independently associated with microalbuminuria when a single ACR threshold was used. When a sex-specific ACR was used, NHB race/ethnicity remained significantly associated with microalbuminuria but sex did not. The use of one ACR value to define microalbuminuria may underestimate microalbuminuria in subjects with higher muscle mass (men) and possibly members of certain racial/ethnic groups.

Microalbuminuria is an independent predictor of cardiovascular disease and all-cause mortality in both diabetic (1) and nondiabetic men and women (2), and may be a stronger indicator for future cardiovascular events than systolic BP (SBP) or serum cholesterol (2). Detecting microalbuminuria is an important screening tool to identify people who are at high risk for cardiovascular events and the progression of kidney disease and who need more intensive therapy compared with subjects with normal albumin excretion rates (3). According to the American Diabetes Association (ADA), the gold standard for measuring urine albumin excretion is a 24-h urine collection (4). However, a more convenient method to detect microalbuminuria is the albumin (μg)/creatinine (mg) ratio (ACR) measured in a random urine specimen (3). Currently, the National Kidney Foundation recommends the use of spot urine ACR obtained under standardized conditions (first voided, morning, midstream specimen) to detect microalbuminuria. The ACR is a more convenient test for patients and may be less prone to errors due to improper collection methods and variations in 24-h protein excretion compared with a random urine specimen (3).

The ADA and the National Kidney Foundation define microalbuminuria as an ACR between 30 to 300 μg/mg in both men and women (3,4). These guidelines do not take into account sex differences in creatinine excretion, and several researchers have advocated sex-specific cutpoints of the ACR to define microalbuminuria (5,6). However, no published studies have demonstrated how the use of a single ACR cutpoint *versus* sex-specific ACR cutpoints measured in random urine samples affects the estimated prevalence of microalbuminuria in a nationally representative sample of US subjects.

The current definition of microalbuminuria as measured by the ACR in a random urine specimen also does not account for racial differences in creatinine excretion. Previous studies have reported urine creatinine excretion rates to be 5 to 30% higher in black subjects compared with white subjects, even after adjusting for weight (7,8). However, the number of subjects in these studies was small, and they were not representative of the entire US population.

Therefore, we examined the distribution of urine albumin and creatinine concentrations and ACR measured in spot urine specimens in a nationally representative sample of men and women and non-Hispanic whites (NHW), non-Hispanic blacks (NHB), and Mexican Americans (MA). Moreover, we evalu-

Received July 26, 2001. Accepted November 17, 2001.
Correspondence to: Dr. Holly J. Mattix, 100 Charles River Plaza, 5th Floor, Boston, MA 02114. Phone: 617-726-7598; Fax: 617-228-7491; E-mail: hmattix@partners.org

1046-6673/1304-1034
Journal of the American Society of Nephrology

ated the association between sex and race/ethnicity and microalbuminuria using the currently recommended ACR value (≥30 μg/mg) and a definition using sex-specific ACR cutpoints (≥17 μg/mg in men and ≥25 μg/mg in women).

Materials and Methods

Study Population

We used data from the National Health and Nutrition Examination Survey III (NHANES III). The NHANES III was designed to be a probability sample of the total civilian noninstitutionalized population, 2 mo of age or older, in the United States and collected health, nutritional, data on 33,994 men, women, and children from 1988 to 1994. Certain subgroups were oversampled such as young children, older people, NHB, and MA. For this study, we used all 6 yr of the study results. Details of the survey design may be found in the NHANES III operation manual (9).

There were 17,030 men and women 20 yr and older who completed both the interview and the physical examination. Of these subjects, we excluded 457 subjects with missing data on urine specimens (181 men and 276 women) and 288 women who were pregnant at the time of the urine collection. For the analysis of the whole population, we excluded subjects with macroalbuminuria as defined by the ADA (ACR ≥300 μg/mg) (186 men and 165 women) (4). In all analyses that used sex-specific ACR cutpoints, 207 men and 139 women with macroalbuminuria (ACR ≥250 in men and ≥355 in women) were excluded. Thus, there were 15,934 people who were 20 yr and older at the time of the home interview who were eligible for the analysis that used ACR ≥30 μg/mg to define microalbuminuria, and there were 15,939 subjects who were eligible for the analyses that used the sex-specific ACR cutpoints.

Exposure

Medical and nutritional history and medication use were collected during a standardized home interview, and a detailed physical examination was completed. Age was defined as the age at the time of the interview, and race/ethnicity was self-reported as NHW, NHB, and, MA. Other race/ethnicities were grouped into the category "other." BP was determined by the average of six readings, three measured during the home interview and three during the physical examination. Diabetes mellitus (DM) was self-reported as being previously diagnosed with DM by a doctor (except during pregnancy) or the current or past use of insulin or diabetes pills. Body mass index (BMI; kg/m^2) was calculated from the weight and height measured during the physical examination.

Microalbuminuria

Solid-phase fluorescence immunoassay was used to measure urinary albumin with a sensitivity level of 0.05 mg/dl. The coefficient of variation for urinary albumin measurement varied from 4.8 to 16.1% over the 6 yr of the study (10). Urine creatinine was measured with the Jaffé rate reaction (Beckman Astra, Brea, CA), and the coefficient of variation ranged from 1.5 to 7.7% throughout the study (10). Spot urine ACR ratios were calculated for all subjects.

To define microalbuminuria in random urine specimens, we used the ACR cutpoint recommended by the ADA (4) and the National Kidney Foundation (3) (ACR ≥30 μg/mg). We also used sex-specific ACR cutpoints as proposed by Warram *et al.* (5), ≥17 and ≥25 μg/mg for men and women, respectively. These sex-specific ACR cutpoints were determined by comparing the ACR in spot urine samples to albumin excretion rates collected from timed urine specimens. The ACR values 17 to 250 μg/mg in men and 25 to 355 μg/mg in women corresponded to 30 to 300 μg/min of urine albumin excretion measured in a timed urine specimen, respectively. These sex-specific ACR cutpoints, ≥17 and ≥25 μg/mg, were the 95th percentile ACR values among 218 nondiabetic, healthy men and women, respectively (5). The units of urine albumin (μg/ml), creatinine concentration (mg/dl), and ACR (μg/mg) correlate with the numeric values of albumin excretion rates (μg/min). Dividing the ACR by 8.84 converts the units (from μg/mg to mg/mmol).

Statistical Analyses

All statistical analyses, including frequencies, *t* tests, multivariate adjusted odds ratios (OR), and 95% confidence intervals (CI), were completed with SAS-callable SUDAAN (Research Triangle Institute, Research Triangle Park, NC) to incorporate sample weights and to adjust for the clusters and strata of the complex sample design and provide prevalence estimates, which reflect the entire US population. The NHANES III data are weighted to account for the probability of selection and to adjust for nonresponse to the interview and physical examination. Categorical variables were compared by the Wald χ^2 test, and mean values of continuous variables were compared between groups by the unpaired *t* test.

Logistic regression was used to calculate odd ratios for microalbuminuria after controlling for multiple covariates simultaneously. The following covariates, selected from previously published reports (1,5,6), were included in the logistic model: age, sex, race/ethnicity, SBP, diastolic BP (DBP), BMI, history of DM, and current smoking. Age was categorized into decades. Race/ethnicity was categorized as NHW, NHB, MA, and other. The sample size of the "other" category was too small to be used analytically, and results from this group are not shown. SBP was categorized into 6 groups: <120, 120 to 130, 131 to 140, 141 to 150, 151 to 160, and >160 mmHg. DBP was categorized into 5 groups: <70, 70 to 80, 81 to 90, 91 to 100, >100 mmHg. BMI was divided into 4 categories on the basis of the criteria of the International Obesity Task Force (11): <18.5, 18.5 to 24.9, 25 to 30, and >30 kg/m^2. Smoking was categorized as current smoker (yes/no).

Results

The characteristics of the population by sex are listed in Table 1. Overall, 51.4% were women, 48.6% were men, 76.1%

Table 1. Characteristics of the US population, National Health and Nutrition Examination Survey III 1988 to 1994, by sex

Variable	Male	Female	*P*
Age (yr)[a]	43.6 ± 0.4	46.0 ± 0.5	<0.0001
SBP (mmHg)[a]	124.5 ± 0.4	120.4 ± 0.5	<0.0001
DBP (mmHg)[a]	76.4 ± 0.3	71.7 ± 0.2	<0.0001
BMI (kg/m^2)[a]	26.6 ± 0.1	26.4 ± 0.1	0.4
Race			
Non-Hispanic white	76.6%	76.3%	0.4
Non-Hispanic black	10.0%	11.4%	0.001
Mexican American	5.6%	4.5%	<0.0001
Diabetes mellitus (%)	4.5	5.8	0.01
Current smoker (%)	32.0	25.3	<0.0001

[a] Mean ± SEM. SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index.

were NHW, 11.0% were NHB, 5.0% were MA, and 7.9% were of other race/ethnicity. The age of the subjects ranged from 20 to 90 yr. Women were older (46.0 *versus* 43.6 yr; $P < 0.0001$) but had lower SBP (120.4 *versus* 124.5 mmHg; $P < 0.0001$) and DBP (71.7 *versus* 76.4 mmHg; $P < 0.0001$) compared with men. History of DM was more frequent among the women ($P = 0.01$), but men were more likely to be current smokers (32.0 *versus* 25.3%; $P < 0.0001$).

Characteristics of the population by race/ethnicity are listed in Table 2. Overall, NHW were significantly older than NHB (46.1 *versus* 41.9 yr; $P < 0.0001$) and MA (46.1 *versus* 37.5 yr; $P < 0.0001$). However, NHB had higher SBP ($P = 0.003$), DBP ($P < 0.0001$), BMI ($P < 0.0001$), and a higher frequency of DM (6.9 *versus* 5.0%; $P = 0.004$) and current smoking (34.0 *versus* 28.7%; $P = 0.002$) compared with NHW. In contrast, MA had lower SBP ($P < 0.0001$) and were less likely to be current smokers ($P = 0.0008$) compared with NHW. However, the prevalence of DM was higher in MA compared with NHW (6.2 *versus* 5.0%; $P = 0.003$).

The mean concentrations and the 5th to 95th percentile values of urine albumin and creatinine concentrations and ACR are presented by sex and race/ethnicity in Table 3. Figures 1 and 2 illustrate the differences in urine albumin and creatinine concentrations and the frequency of microalbuminuria by using a single ACR and by using sex-specific ACR cutpoints by sex and race, respectively. Mean urine albumin concentrations were not significantly different between men and women ($P = 0.8$), but men had significantly higher mean urine creatinine concentrations ($P < 0.0001$) and lower ACR ($P < 0.0001$). By use of a single ACR cutpoint, there were an estimated 12.9 million people in the US population with microalbuminuria and more than 3.1 million more women with microalbuminuria

Table 2. Characteristics of the US population, National Health and Nutrition Examination Survey III 1988 to 1994, by race/ethnicity

Variable	Non-Hispanic White	Non-Hispanic Black	P[b]	Mexican American	P[b]
Age (yr)[a]	46.1 ± 0.6	41.9 ± 0.4	<0.0001	37.5 ± 0.4	<0.0001
SBP (mmHg)[a]	122.7 ± 0.5	124.4 ± 0.4	0.003	119.7 ± 0.3	<0.0001
DBP (mmHg)[a]	73.8 ± 0.2	75.4 ± 0.3	<0.0001	73.0 ± 0.4	0.08
BMI (kg/m^2)[a]	26.3 ± 0.1	27.7 ± 0.1	<0.0001	27.4 ± 0.1	<0.0001
Male sex (%)	48.5	45.1	0.002	54.0	<0.0001
Diabetes mellitus (%)	5.0	6.9	0.004	6.2	0.003
Current smoker (%)	28.7	34.0	0.002	23.3	0.0008

[a] Mean ± SEM. SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index.
[b] Non-Hispanic black and Mexican American race/ethnicity are compared to non-Hispanic white.

Table 3. Distribution of urine albumin and creatinine concentrations in the US population, National Health and Nutrition Examination Survey III 1988 to 1994, by sex and race/ethnicity[a]

Variable	All Subjects	Men	Women	NHW	NHB	MA
Urinary albumin[b] (μg/ml)						
mean ± SEM	14.6 ± 0.5	14.7 ± 0.6	14.5 ± 0.7	13.6 ± 0.6	21.4 ± 0.8 A	15.7 ± 1.0
5–95th percentile	0.7–50.5	0.7–49.0	0.7–52.8	0.7–45.0	0.9–88.8	0.5–50.4
Urinary creatinine[b] (mg/dl)						
mean ± SEM	129.3 ± 1.4	152.0 ± 2.0	108.0 ± 1.5 A	123.1 ± 1.6	168.2 ± 1.6 A	139.0 ± 2.0 A
5–95th percentile	21.2–276.3	30.6–299.4	18.1–245.9	20.3–268.5	36.7–323.7	23.6–282.3
Cr/BMI	5.0 ± 0.1	5.9 ± 0.1	4.3 ± 0.1 A	4.8 ± 0.1	6.4 ± 0.1 A	5.2 ± 0.1 B
ACR[b] (μg/mg)						
mean ± SEM	12.5 ± 0.4	10.5 ± 0.5	14.4 ± 0.5 A	12.3 ± 0.5	14.5 ± 0.5 C	12.1 ± 0.5
5–95th percentile	1.0–46.6	0.8–36.8	1.2–56.7	1.2–43.0	0.6–67.0	0.6–44.1
Microalbuminuria						
ACR ≥30–299[b]	7.6%	6.0%	9.2% A	7.2%	10.2% A	7.2%
population estimate in millions	12.9	4.9	8.0	9.3	1.8	0.6
ACR ≥17–249[c] in men and ≥25–354[c] in women	10.7%	10.4%	11.0%	10.3%	13.6% B	9.9%
population estimate in millions	18.4	8.6	9.8	13.6	2.5	0.9

[a] NHW, non-Hispanic white; NHB, non-Hispanic black; MA, Mexican American; ACR, urine albumin (μg)/creatinine (mg) ratio; Cr/BMI, urine creatinine (mg/dl)/body mass index (kg/m^2). P values are as follows: A, $P < 0.0001$; B, $P < 0.001$; C, $P = 0.02$.
[b] Data from subjects with ACR ≥300 are excluded.
[c] Data from men with ACR ≥250 and women with ACR ≥355 are excluded.

than men (4.9 million men and 8.0 million women). The sex-specific ACR cutpoints were lower for both men and women (≥17 μg/mg for men and ≥25 μg/mg for women). Thus, the use of sex-specific ACR cutpoints increased the total estimate of people in the US population with microalbuminuria from 12.9 million to 18.4 million, with approximately 1.2 million more women with microalbuminuria than men (8.6 million men and 9.8 million women).

Compared with NHW, NHB had higher urinary albumin concentrations (21.4 *versus* 13.6 μg/ml; $P < 0.0001$), urine creatinine concentrations (168.2 *versus* 123.1 mg/dl; $P < 0.0001$), and ACR (14.5 *versus* 12.3 μg/mg; $P = 0.02$). The ratio of urine creatinine concentration (mg/dl)/BMI (kg/m^2) was also significantly different between the 2 groups ($P < 0.0001$). Regardless of the ACR cutpoints used to define microalbuminuria, the frequency of microalbuminuria was significantly higher in NHB compared with NHW.

MA did not have significantly different urine albumin concentrations compared with NHW, but urine creatinine concentrations were significantly higher (139.0 *versus* 123.1 μg/mg; $P < 0.0001$). The frequency of microalbuminuria as defined by an ACR ≥30 μg/mg or by sex-specific cutpoints was not statistically different between MA and NHW.

The age-adjusted and the multivariate adjusted OR by sex and race/ethnicity are listed in Table 4. In the age-adjusted model with microalbuminuria as defined by ACR ≥30 μg/mg, female sex was significantly associated with microalbuminuria (OR, 1.47; 95% CI, 1.18 to 1.82). The association was slightly increased after adjusting for race/ethnicity, DM, SBP, DBP, BMI, and smoking, (OR, 1.62; 95% CI, 1.29 to 2.05). However, there was no association between sex and microalbuminuria in the age-adjusted or multivariate models when the sex-specific ACR cutpoints (ACR ≥17 μg/mg in men and ≥25 μg/mg in women) were used.

After adjusting for age, both NHB and MA race/ethnicity were independently associated with microalbuminuria as defined by the ACR ≥30 μg/mg. In the multivariate model, NHB race/ethnicity remained significant (OR, 1.34; 95% CI, 1.12 to 1.61), but MA race/ethnicity (OR, 1.24; 95% CI, 0.99 to 1.54) did not. Similar results were noted when sex-specific ACR cutpoints were used to define microalbuminuria within the racial groups, but the CI for MA race/ethnicity did not include 1.0.

Discussion

In this study of a nationally representative sample of subjects, we illustrate the potential pitfalls in standardizing urine albumin excretion to urine creatinine, and using a single ACR threshold was used to define microalbuminuria in men and women. We found that the use of a single ACR threshold to define microalbuminuria estimated that the total number of women with microalbuminuria in the US population was 60% higher than the total number of men with microalbuminuria. Previous studies have found conflicting results regarding the association between sex and microalbuminuria; this was most likely due to the different methods used to detect microalbuminuria (ACR *versus* timed urine collection) (13–16). Studies that used one ACR threshold measured in random urine specimens to define microalbuminuria found a higher frequency of microalbuminuria in women compared with men (12,13). In contrast, studies that used timed urine collections to measure microalbuminuria found a higher frequency of microalbuminuria among the men (14,15).

In this study, the higher frequency of microalbuminuria among women, defined by an ACR ≥30 μg/mg, was in part due to lower urine creatinine concentrations and not a higher urine albumin concentration. Creatinine is a metabolic byproduct of skeletal muscle creatine and phosphocreatine metabolism and is thus lower in subjects with lower muscle mass such as women or the elderly (7). We found significantly higher levels of urine creatinine in men but no significant differences in urine albumin concentration. Because the denominator in the ACR ratio was significantly lower in women, the multivariate adjusted OR for microalbuminuria in women, defined by an ACR ≥30, was 50% higher compared with men.

Several investigators have previously advocated using separate ACR cutpoints for the detection of microalbuminuria in men and women (5–6). Warram *et al.* (5) determined sex-specific ACR values by comparing the ACR in spot urine samples to albumin excretion rates measured in timed urine specimens. The ACR values 17 μg/mg in men and 25 μg/mg in women corresponded to 30 and 31 μg/min of urine albumin excretion, respectively. These ACR cutpoints were also the 95th percentile values among 218 nondiabetic healthy men and women. Similarly, Connell *et al.* (6) collected timed overnight urine samples in 187 diabetic and 105 control subjects and found that an ACR of 4.0 mg/mmol (≅22 μg/mg) correlated with an albumin excretion rate of 35 μg/min in men and 23 μg/min in women.

We demonstrated significant differences in urine creatinine concentrations between NHW, NHB, and MA, as noted by previous researchers (7,8). In addition, the ratio urinary creatinine concentration/BMI was significantly higher among NHB compared with NHW. These findings are consistent with previous studies, which demonstrated higher 24-h urinary creatinine excretion per kilogram in black subjects compared with nonblack subjects (7,8). Differences in creatinine excretion are likely in part due to differences in muscle mass; some researchers have demonstrated higher skeletal muscle mass in NHB men and women compared with whites (16,17). Although urine creatinine concentrations in NHB and MA were higher than NHW (which would decrease the ACR), the frequency of microalbuminuria in these groups was significantly higher. Thus, the frequency of microalbuminuria in NHB and MA may have been underestimated. To our knowledge, no previous studies have compared individual 24-h urine collections and spot urine specimens in various race/ethnicity groups to determine appropriate ACR thresholds for different race/ethnicity groups such as NHB. Future studies should investigate appropriate ACR thresholds for different racial/ethnic groups.

Additionally, we found NHB race/ethnicity was independently associated with microalbuminuria when one ACR threshold or sex-specific ACR cutpoints was used. Savage *et al.* (15) noted a higher prevalence of microalbuminuria in NHB

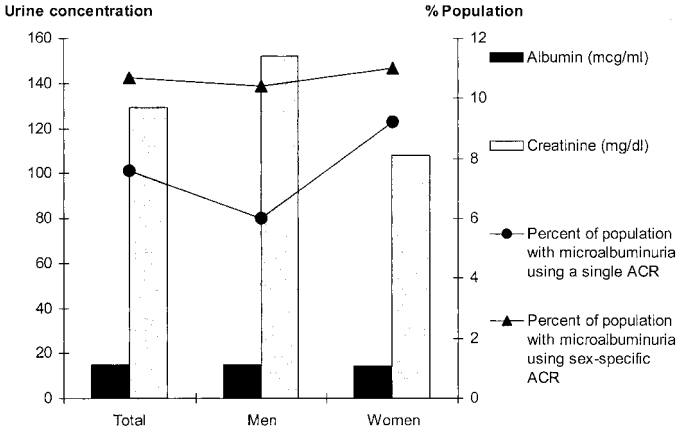

Figure 1. Graph showing urine albumin and creatinine concentrations and frequency of microalbuminuria by sex using a single albumin/creatinine ratio (ACR) threshold and sex-specific ACR cutpoints. Single ACR, 30 to 229 μg/mg; sex-specific ACR, 17 to 249 μg/mg in men and 25 to 354 μg/mg in women.

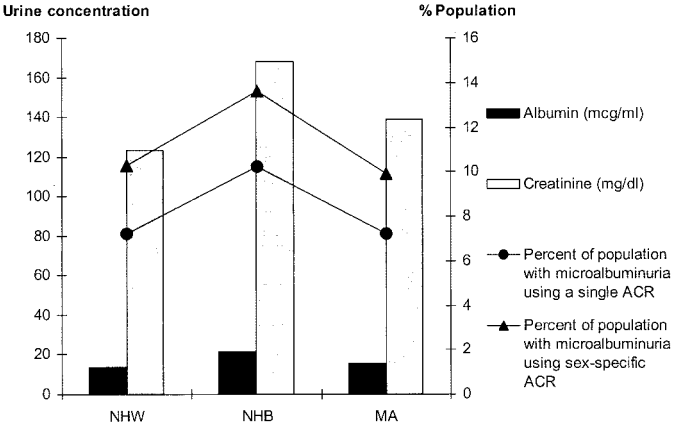

Figure 2. Graph showing urine albumin and creatinine concentrations and frequency of microalbuminuria by race using a single albumin/creatinine ratio (ACR) threshold and sex-specific ACR cutpoints. Single ACR, 30 to 299 μg/mg; sex-specific ACR, 17 to 249 μg/mg in men and 25 to 354 μg/mg in women. NHW, non-Hispanic white; NHB, non-Hispanic black; MA, Mexican American.

with type 2 DM. However, after adjusting for hypertension, age, and other risk factors, race/ethnicity was no longer independently associated with microalbuminuria in that study (15). In other investigations, the association between race and microalbuminuria was not assessed because of the homogenous population, which did not reflect the demographics of the United States (18,19), or it was not reported (13). In our study, NHB race/ethnicity remained independently associated with microalbuminuria even after adjusting for other risk factors, including age, DM, SBP, DBP, BMI, and smoking.

NHB had higher SBP and DBP compared with NHW, and previous reports have linked elevated SBP and DBP with microalbuminuria (6,20,21). Although we controlled for SBP and DBP in our model, we did not have information on 24-h BP measurements, which may be a more accurate measure of racial differences in terms of BP (22). The prevalence of DM was also significantly higher among NHB compared with NHW. Although we adjusted for DM in the multivariate model, we did not adjust for undiagnosed diabetes, which may partially account for the higher prevalence of microalbuminuria in this group.

In summary, urine creatinine concentrations differ between men and women and between different racial/ethnic groups. Therefore, standardizing urine albumin concentrations to creatinine (*i.e.*, ACR) may underestimate microalbuminuria in subjects with higher muscle mass (men) and possibly in certain racial/ethnic groups, such as NHB, or overestimate it in subjects with lower muscle mass (women). Future research studies that use the ACR to define microalbuminuria should use sex-specific ACR cutpoints to help avoid the potential problems of

Table 4. Multivariate adjusted odds ratio for microalbuminuria using the ADA-NKF definition and a sex-specific definition[a]

Variable	ADA-NKF Definition of Microalbuminuria[b]		Sex-Specific Definition of Microalbuminuria[c]	
	Age-Adjusted Odds Ratio (95% CI)	Multivariate Adjusted Odds Ratio[d] (95% CI)	Age-Adjusted Odds Ratio (95% CI)	Multivariate Adjusted Odds Ratio[d] (95% CI)
Sex				
male	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
female	1.47 (1.18–1.82)	1.62 (1.29–2.05)	0.94 (0.81–1.09)	0.98 (0.83–1.16)
Race				
NHW	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
NHB	1.64 (1.42–1.91)	1.34 (1.12–1.61)	1.78 (1.49–2.13)	1.30 (1.11–1.53)
MA	1.36 (1.14–1.62)	1.24 (0.99–1.54)	1.41 (1.14–1.71)	1.22 (1.03–1.45)

[a] ADA-NKF, American Diabetes Association–National Kidney Foundation; NHW, non-Hispanic white; NHB, non-Hispanic black; MA, Mexican American.
[b] ACR ≥30–299 μg/mg in men and women.
[c] ACR ≥17–249 μg/mg in men and ≥25–354 μg/mg in women.
[d] Adjusted for sex, race/ethnicity, age, systolic and diastolic blood pressure, body mass index, diabetes mellitus, and current smoking.

underestimating microalbuminuria in subjects with high urine creatinine excretion (*e.g.*, men) and overestimating microalbuminuria in subjects with low urine creatinine excretion (*e.g.*, women). Results from prospective studies should be used to define risk of abnormal urine albumin excretion at different levels of ACR. Studies are also needed to determine appropriate ACR thresholds for different race/ethnicity groups.

NHB race/ethnicity was independently associated with microalbuminuria despite having higher urine creatinine concentrations. Because NHB have been identified as a high risk group for the association between microalbuminuria and increased cardiovascular and renal disease (1), detecting microalbuminuria in these individuals is critical so that preventive measures may be implemented early (1). The statistically significant association between race/ethnicity and microalbuminuria found in this study highlights the importance of race as an independent risk factor for both kidney and cardiovascular disease. [Printer: References (9,24) are cited here for parsing. Please delete this parenthetical information.]

Acknowledgments

This project was supported by a grant from the American Kidney Fund (HJM). GC was supported in part by a grant from the National Institute of Health (grant DK59583).

References

1. Rossing P, Hougaard P, Borch-Johnsen K, Parving H: Predictors of mortality in insulin dependent diabetes: 10-year observational follow up study. *Br Med J* 313: 779–784, 1996
2. Ljungman S, Wikstrand J, Hartford M, Berglund G: Urinary albumin excretion: A predictor of risk of cardiovascular disease—A prospective 10-year follow-up of middle aged nondiabetic normal and hypertensive men. *Am J Hypertens* 9: 770–778, 1996
3. Keane WF, Eknoyan G: Proteinuria, albuminuria, risk, assessment, detection, elimination (PARADE): A position paper of the National Kidney Foundation. *Am J Kidney Dis* 33: 1004–1010, 1999
4. American Diabetes Association: Clinical practice recommendations 2001: Diabetic nephropathy. *Diabetes Care* 24[Suppl 1]: S69–S72, 2001
5. Warram JH, Gearin G, Laffel L, Krolewski AS: Effect of duration of type I diabetes on the prevalence of stages of diabetic nephropathy defined by urinary albumin/creatinine ratio. *J Am Soc Nephrol* 7: 930–937, 1996
6. Connell SJ, Hollis S, Tieszen KL, McMurray JR, Dornan TL: Gender and the clinical usefulness of the albumin:creatinine ratio. *Diabet Med* 11: 32–6, 1994
7. James GD, Sealey JE, Alderman M, Ljungman S, Mueller FB, Pecker MS, Laragh JH: A longitudinal study of urinary creatinine and creatinine clearance in normal subjects: Race, sex, and age differences. *Am J Hypertens* 1: 124–131, 1988
8. Goldwasser P, Aboul-Magd A, Maru M: Race and creatinine excretion in chronic renal insufficiency. *Am J Kidney Dis* 30: 16–22, 1997
9. National Center for Health Statistics: *Survey Design of the Third National Health and Nutrition Examination Survey, 1988–1994*, Hyattsville, MD, Centers for Disease Control and Prevention, 1996
10. National Center for Health Statistics: *Third National Health and Nutrition Examination Survey, 1988–1994, Reference Manuals and Reports: Manual for Medical Technicians and Laboratory Procedures Used for NHANES III*. Hyattsville, MD, Centers for Disease Control and Prevention, 1996
11. World Health Organization: *Obesity: Preventing and Managing the Global Epidemic: Report of a WHO Consultation on Obesity, Geneva, June 3–5, 1997*. Geneva, World Health Organization, 1998
12. Festa A, D'agostino R Jr, Howard G, Mykkänen L, Tracy RP, Haffner SM: Inflammation and microalbuminuria in nondiabetic and type 2 diabetic subjects: The Insulin Resistance Atherosclerosis study. *Kidney Int* 58: 1703–1710, 2000
13. Gerstein HC, Mann JFE, Pogue J, Dinneen SF, Hallé JP, Hoogwerf B, Joyce C, Rashkow A, Young J, Zinman B, Yusuf S, for the HOPE Study Investigators: Prevalence and determinants of microalbuminuria in high-risk diabetic and nondiabetic patients in the Heart Outcomes Prevention Evaluation study. *Diabetes Care* 23[Suppl 2]: B35–B39, 2000
14. Martinez MA, Moreno A, Aguirre de Cárcer A, Cabrera R, Rocha R, Torre A, Nevado A, Ramos T, Neri J, Antón G, Miranda I, Fernández P, Rodriguez E, Miguel A, Martínez JL, Rodríguez M, Eisman C, Puig JG, for the MAPA-Madrid Working Group: Frequency and determinants of microalbuminuria in mild hypertension: A primary-care based study. *J Hypertens* 19: 319–326, 2001
15. Savage S, Nagel NJU, Estacio RO, Lukken N, Schrier RW: Clinical factors associated with urinary albumin excretion in type II diabetes. *Am J Kidney Dis* 25: 836–844, 1995
16. Ama PFM, Simoneu JA, Boulay MR, Serresse O, Theriault G, Bouchard C: Skeletal muscle characteristics in sedentary black and Caucasian males. *Am J Physiol* 61: 1758–1761, 1986
17. Ortiz O, Russell M, Daley TL, Baumgartner RN, Waki M, Lichtman S, Wang J, Pierson Jr. RN, Heymsfield SB: Differences in skeletal muscle and bone mineral mass between black and white females and their relevance to estimates of body composition. *Am J Clin Nutr* 55: 8–13, 1992
18. Hillege HL, Janssen MT, Bak AAA, Diercks GFH, Grobbee DE, Crijns HJGM, Van Gilst WH, De Zeeuw D, De Jong PE: Microalbuminuria is common also in a nondiabetic, nonhypertensive population, and an independent indicator of cardiovascular risk factors and cardiovascular morbidity. *J Intern Med* 249: 519–526, 2001
19. Pontremoli R, Antonella S, Ravera M, Nicolella C, Viazzi F, Tirotta A, Ruello N, Tomolillo C, Castello C, Grillo G, Sacchi G, Deferrari G: Prevalence and clinical correlates of microalbuminuria in essential hypertension: The MAGIC study. *Hypertension* 30: 1135–1143, 1997
20. Mykkanen L, Haffner SM, Kuusisto J, Pyorala K, Laakso M: Microalbuminuria precedes the development of NIDDM. *Diabetes* 43: 552–557, 1994
21. Jensen JS, Borch-Johnsen K, Jensen G, Feldt-Rasmussen B: Atherosclerotic risk factors are increased in clinically healthy subjects with microalbuminuria. *Atherosclerosis* 112: 245–252, 1995
22. Gretler DD, Fumo MT, Nelson KS, Murphy MB: Ethnic differences in circadian hemodynamic profile. *Am J Hypertens* 7: 7–14, 1997