

Obesity, Albuminuria, and Urinalysis Findings in US Young Adults from the Add Health Wave III Study

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Background and objectives: Obesity has been associated with kidney disease in adults. This study was designed to evaluate the association of obesity with an early marker of kidney disease, albuminuria, among young adults.

Design, setting, participants, & measurements: Urinalysis ($n = 9371$), albumin-to-creatinine ratio ($n = 4463$), and body mass index (kg/m^2) were measured in the Add Health Wave III cohort (2001 to 2002), a multiethnic sample of young adults followed for approximately 6 yr. Multivariate logistic regression modeled the association of sex-specific albuminuria with body mass index, adjusted for sample weights, sex, race, ethnicity, and glycosuria.

Results: Urinalysis revealed that 0.8% had proteinuria, 4.6% had hematuria, 0.2% had combined hematuria and proteinuria, and 1.5% had glycosuria. Albuminuria prevalence was 4.4%. Mean body mass index was higher among those with albuminuria compared with those without. There were no associations between body mass index categories of 25 to <30 or 30 to <35 kg/m^2 with albuminuria compared with the lowest body mass index (<25 kg/m^2); however, the highest category ($\geq 35 \text{ kg}/\text{m}^2$) was associated with albuminuria, compared with the lowest category (OR = 1.76, 95% CI: 1.02 to 3.04). Glycosuria (OR = 4.0; 95% CI: 1.5 to 11.1, $p < 0.01$) as well as increasing body mass index during the 6-yr follow-up (OR: 1.07 per unit change in kg/m^2 ; 95% CI: 1.00 to 1.13, $p = 0.04$) were also associated with albuminuria.

Conclusions: Given the increasing prevalence of obesity, the association of albuminuria associated with obesity in young adults is particularly concerning. Obesity may be a target for primary prevention of kidney and cardiovascular disease.

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More than 60% of adults who live in the United States are overweight (1). Overweight is associated with increasing rates of hypertension, diabetes, and dyslipidemia (2). This constellation of risk factors is also associated with end-stage kidney disease (ESKD), the prevalence of which has increased despite the availability of interventions to control blood sugar and blood pressure (3). In the past several years, various studies (4–8) have highlighted the importance of higher body mass as a risk factor for kidney impairment; however, few studies have focused on renal consequences of obesity among young adults or in the early stages of chronic kidney disease (CKD).

The prevalence of early CKD has also increased in the past two decades (9). Albuminuria is an early marker of CKD, as well as a predictor of cardiovascular disease and mortality in the general

population (10–12), with well-documented correlates and consequences of albuminuria in older adults, including hypertension, diabetes, and the metabolic syndrome (12,13). Because albuminuria appears early in the natural history of kidney disease, it is a potential target of primary prevention (14).

The purpose of this study was to assess the hypothesis that body mass index (BMI) and obesity were related to albuminuria in young adults who participated in the third wave of the National Longitudinal Study of Adolescent Health (Add Health Wave III). A better understanding of this association in this age group will improve our understanding of cause as well as guide prevention and intervention. This study also allowed assessment of urinalysis results among a large population of young adults, which has not been well described in this age group.

Concise Methods

Study Population

A subsample of young adults who were aged 18 to 26 yr and participated in the Add Health study were evaluated for this study. The Add Health cohort was originally selected as a nationally representative school-based study of youths aged 12 to 19 (Wave I, 1994 to 1995) to assess health-related behaviors and their outcomes in young adulthood. The study used multistage, stratified, school-based, clustered sampling to ensure that the schools were representative of all US

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To obtain data files from Add Health: Add Health, Carolina Population Center, 123 W. Franklin Street, Chapel Hill, NC 27516-2524.

schools (15). Briefly, 80 high schools, each paired with a feeder middle school, were selected from all high schools with more than 30 students. Within schools, students were stratified by grade and sex, then randomly selected within stratum with approximately 200 selected from each school pair. Oversampling was conducted within select minority groups. A total of 20,475 individuals were enrolled in Wave I. Wave III, conducted between 2001 and 2002, included 15,170 (76%) Wave I respondents. Study procedures were approved by the institutional review board of the University of North Carolina at Chapel Hill.

Data and Specimen Collection and Definitions

Participants entered directly into a computer self-reported survey responses on demographics, education, socioeconomic status, height, weight, medical conditions, exercise frequency, and smoking history. Field workers also measured height and weight. BMI was calculated as weight in kilograms divided by height in meters squared (kg/m^2), using measured height and weight or self-reported values when not measured ($n = 136$).

Participants provided a random (*i.e.*, any time of day) first-stream 15- to 20-ml urine sample with the primary purpose for evaluation of sexually transmitted diseases in participants and their romantic partners (16). Urine samples were stored at 4°C until shipped overnight with ice packs in insulated containers. Automated urinalysis was performed using the Roche Chemstrip 10 UA urine dipsticks and a Roche Urisys 1800 System Analyzer (Roche Diagnostics, Indianapolis, IN) within 72 h of collection. The remaining urine was stored at -70°C for measurement of albuminuria approximately 1 wk later.

A total of 12,566 urine samples were available. Samples that were at room temperature, improperly shipped, or insufficient were discarded ($n = 390$). All other samples ($n = 12,176$) underwent urinalysis evaluation. Exclusions were applied later, when urine results were merged with the full Add Health data set. Urine samples from romantic partners ($n = 1308$) and from pregnant ($n = 390$) or menstruating ($n = 1107$) women were excluded, leaving 9371 samples for urinalysis evaluation.

Urinalysis results were defined as positive for protein when >30 mg/dl (0.30 g/L), red blood cells (RBC) when >25 erythrocytes per μL , white blood cells (WBC) when >25 per μL , and glycosuria when urine glucose was >50 mg/dl (2.8 mmol/L) (17). Two quality control urinalyses were conducted each day samples were evaluated.

Urine albumin and creatinine were measured by the Roche Cobas Mira analyzer (Roche Diagnostics, Indianapolis, IN). Albumin was quantified using the Roche Tina-quant Albumin reagent, an immunoturbidimetric method for the *in vitro* measurement of human albumin in the urine, and measured spectrophotometrically. Albuminuria was defined using sex-specific albumin-to-creatinine ratios of ≥ 17 mg/g in men and ≥ 25 mg/g in women (18).

Albuminuria was evaluated in a subset of respondents, chosen by BMI to maximize statistical power. Of the 10,868 adequate specimens from Wave I participants (romantic partners excluded), 2100 samples were randomly selected from three BMI groups ($n = 6300$): <25 , 25 to 30, and >30 kg/m^2 . To limit false-positive albuminuria values, we also applied exclusions on the basis of the population-based Prevention of Renal and Vascular End Stage Disease (PREVEND) study (17,19) by excluding pregnant ($n = 224$) or menstruating ($n = 680$) women and those with ≥ 75 WBC/ μL ($n = 834$) or >50 RBC/ μL ($n = 139$; of these 834 and 139 samples, 40 were in the same participant). Urinalysis-based exclusion criteria were applied to rule out albuminuria associated with urinary tract infections or non-kidney-related hematuria; therefore, they differ from definitions used to describe urinalysis findings, with the exception of glycosuria. Upon applying exclusion criteria after urine results were merged with the full Add Health data set, 4463 respondents were included in the albuminuria analysis.

The obesity category was further divided into BMI from 30 to <35

kg/m^2 (class I obesity) and BMI of ≥ 35 kg/m^2 (class II or greater obesity) (20). History of hypertension and diabetes was self-reported. Because adult values for obesity are not applicable to adolescent BMI, age- and sex-specific percentiles of BMI based on 2000 Centers for Disease Control and Prevention growth charts was used (21), then categorized as ≤ 50 th, >50 th and ≤ 75 th, >75 th and ≤ 95 th, and >95 th percentiles. Change in BMI from Wave I to Wave III was also evaluated. Additional measures used in this study included education, health insurance status (insured *versus* noninsured), having smoked at least one cigarette within the past 30 d, and any or heavy exercise two or more times in the week before the interview.

Statistical Analyses

Descriptive statistics included frequencies and percentages or means with standard errors (SE) for demographic, health characteristics, and urinalysis results. Logistic regression was used to evaluate the association of BMI categories with albuminuria. We also assessed associations of albuminuria with race, sex, Wave I BMI, education, health insurance, diabetes, glycosuria, hypertension, exercise, low birth weight, and smoking. Variables that were associated with albuminuria in univariate analysis or that influenced the association between BMI and albuminuria by $\geq 20\%$ were retained in the final multivariate model. Multiplicative interactions of BMI with sex, race, and glycosuria were explored using logistic regression models. Interaction terms with $P < 0.15$ (P interaction) led to evaluation of separate models by interaction terms. Logistic regression results are expressed as odds ratios (OR) with 95% confidence intervals (CI) and P values. All analyses were weighted for sample selection probabilities and nonresponse using SUDAAN 9.0 (Research Triangle Institute, Research Triangle Park, NC).

Results

The Add Health respondents for whom urinalysis ($n = 9371$) and albuminuria ($n = 4463$) were evaluated for this study were similar to the overall Add Health Wave III respondents ($n = 15,197$) with respect to age, education, health insurance, diabetes, hypertension, and smoking (Table 1). Because of oversampling of overweight individuals and exclusion of pregnant and menstruating women, BMI and sex were significantly different ($P < 0.05$) in the albuminuria assessment group compared with the overall cohort. Race/ethnicity and exercise were also different between these two groups ($P < 0.05$).

Elevations of urine protein, RBC, and WBC are depicted in Figure 1. The most common findings were WBC $>25/\mu\text{L}$ in 14.7% of respondents ($n = 1382$), followed by hematuria (RBC $>25/\mu\text{L}$) in 4.6% ($n = 432$) and proteinuria (>30 mg/dl) in 0.8% ($n = 73$). As shown in Figure 1, proteinuria in the absence of other urinary abnormalities was seen in 0.5%, with the other 0.3% overlapping with hematuria, increased WBC, or both. Glycosuria was evident in 1.5% ($n = 142$) of respondents.

The median measured albumin-to-creatinine ratio ($n = 4463$) was 2.3 mg/g (range 0.0 to 7641.0). Albuminuria was prevalent in 4.4% ($n = 194$) of respondents. Among those with albuminuria, dipstick proteinuria was positive (≥ 30 mg/dl) in 11.9% ($n = 23$). With the exception of BMI, those with and without albuminuria were not statistically different across many characteristics, although those with albuminuria had consistently higher representation of black race, Hispanic ethnicity, hypertension, and glycosuria (Table 2). Mean BMI was significantly higher ($P = 0.01$) among those with albuminuria (29.4 ± 0.6

Table 1. Demographic and health characteristics of the Add Health Wave III study respondents

Characteristics	All Add Health Respondents (n = 15,197)	Sample with Urinalysis Evaluation (n = 9371) ^b	Sample with Albuminuria Measurement (n = 4463) ^c
Age (yr; mean ± SD)	22.0 ± 1.77	21.9 ± 1.77	21.9 ± 1.74
Male (n [%])	7167 (47)	5112 (55)	2740 (61) ^e
Ethnicity (n [%])	8375 (55)	5276 (56)	2574 (58) ^e
white			
black	3225 (21)	1921 (21)	841 (19)
Native American	118 (1)	72 (1)	33 (1)
Asian	1002 (7)	604 (6)	290 (6)
Hispanic	2477 (16)	1498 (16)	725 (16)
BMI ≥95th percentile at Wave I (n [%]) ^a	1460 (13) ^f	964 (14) ^g	613 (19) ^h
BMI (kg/m ² ; mean ± SD)	26.70 ± 6.39 ⁱ	26.75 ± 6.39 ^j	28.20 ± 6.64 ^e
BMI category (kg/m ² ; n [%])			
<25	7325 (49)	4458 (48)	1546 (35)
25 to <30	4146 (28)	2638 (28)	1489 (33)
30 to <35	1952 (13)	1197 (13)	774 (17)
≥35	1638 (11)	1011 (11)	654 (15)
Education ≤12 yr (n [%])	6998 (46)	4344 (46)	1997 (45)
Health insurance (n [%])	11,481 (76)	6987 (75)	3343 (75)
Conditions (n [%]) ^d			
diabetes	152 (1)	89 (1)	46 (1)
glycosuria	NA	142 (1.5)	64 (1.4)
diabetes and/or glycosuria	NA	194 (2)	95 (2)
hypertension	846 (6)	538 (6)	283 (6)
Exercise (n [%])			
≥2 times/wk	7727 (51)	4771 (51)	2373 (53) ^e
heavy exercise ≥2 times/wk	5006 (33)	3295 (35)	1653 (37)
Smoked within 30 d	4913 (32)	3164 (34)	1466 (33)

^aBMI, body mass index.

^bExcluding women who were pregnant or menstruating at the time of the collection.

^cExcluding women who were pregnant or menstruating at the time of the collection as well as any participant with white blood cells ≥75 and hematuria >50 from urinalysis results.

^dHypertension and diabetes history were by self-report.

^e*P* < 0.05, sample with albuminuria versus all Add Health respondents.

^fA total of 4268 respondents were missing BMI.

^gA total of 2617 respondents were missing BMI.

^hA total of 1178 respondents were missing BMI.

ⁱA total of 136 respondents were missing BMI.

^jA total of 67 respondents were missing BMI.

kg/m²) compared with those without albuminuria (28.3 ± 0.2 kg/m²; Table 2). There was a nonlinear association between BMI and albuminuria, with only the highest BMI category (≥35 kg/m²) related to albuminuria compared with the reference group (<25 kg/m²), with an OR of 1.76 (95% CI 1.02 to 3.04; *P* = 0.04; (Table 3), controlling for sex, ethnicity, and glycosuria (Table 3). Consistent results were seen when adjusting for additional covariates including education, hypertension, health insurance, diabetes or both diabetes and glycosuria, exercise, and smoking. The only other measure that was associated with albuminuria was glycosuria (OR 4.04; 95% CI 1.47 to 11.1; *P* < 0.01), controlling for sex, ethnicity, and BMI (Table 3).

Heterogeneity of the association between albuminuria and the highest BMI category (≥35 kg/m²) was evident by sex (*P* interaction = 0.08), ethnicity (*P* interaction = 0.02), and glycosuria (*P* interaction = 0.01). Figure 2 shows the unadjusted prevalence of albuminuria by class II or greater obesity (≥35 kg/m²) within race/ethnicity and sex subgroups. White and black men showed much greater prevalence of albuminuria in the class II or higher group compared with others. Separate models were evaluated within combined sex and race/ethnicity categories, but CI were too wide to provide accurate estimates; however, the models suggested that the strongest associations between albuminuria and the highest BMI category

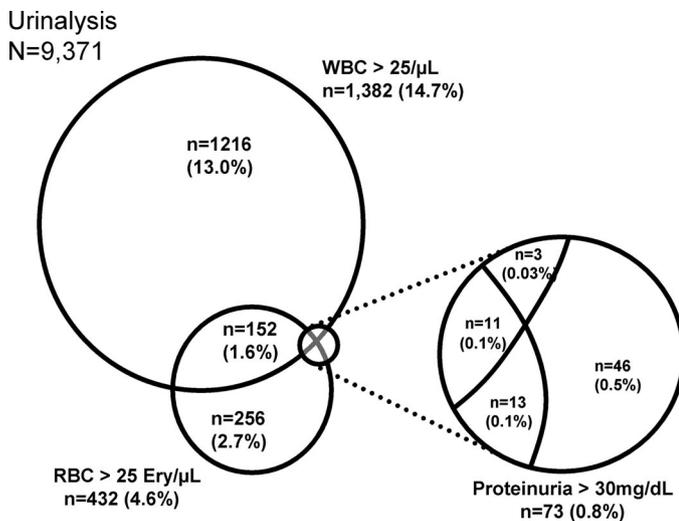


Figure 1. Urinalysis results of proteinuria and hematuria, with elevated white blood cells (WBC) also shown because their presence could lead to a false-positive evaluation of protein excretion. Hematuria (red blood cells [RBC] >25/ μ L) was found in 4.6% ($n = 432$) and proteinuria (>30 mg/dl) in 0.8% ($n = 73$). Proteinuria may have been falsely elevated as a result of the presence of WBC in 0.13%, meaning that approximately 0.6% had elevated proteinuria, with 0.1% having both proteinuria and hematuria.

(≥ 35 kg/m²) were among white and black men. Because only 2% of participants had glycosuria, no separate modeling was done among this group.

At Wave I, 13% of respondents were ≥ 95 th percentile of age- and sex-specific growth charts. Wave I BMI neither as a continuous measure ($P = 0.33$) nor as a categorical measure, including the highest BMI category (≥ 95 th versus <50th percentile; $P = 0.45$) were related to albuminuria; however, each kg/m² unit increase in BMI between Wave I and Wave III over approximately 6 yr was associated with increased odds for albuminuria (OR 1.07; 95% CI 1.00 to 1.13; $P = 0.04$), in an adjusted model controlling for sex, ethnicity, glycosuria, and Wave I BMI.

Discussion

This study supports an association between morbid obesity and the presence of albuminuria in young adults, because only the highest level of BMI (≥ 35 kg/m²) was associated with albuminuria. The association was particularly evident among both black and white men. This study also reveals a prevalence of elevated glycosuria that is considerably higher than in previous reports, whereas other urinalysis results are within range of previous studies, although there have been few estimates in young adults.

Our findings are consistent with other reports that link higher BMI with ESKD (7,8), CKD (4–6), and albuminuria (4,22–27). Two cohort studies have shown evidence of an association between higher BMI and development of ESKD (7,8), with one study finding an association only in men (8), consistent with our findings. In another study, ESKD risk increased across categories of obesity among participants who were followed for an average of 26 yr (7), with the strongest associa-

tions among young adults (age ≤ 40). Several studies (4–6) have also shown an association between higher BMI and risk for CKD, defined by reduced estimated GFR.

Similar to our study, Verhave *et al.* (22) found an association between BMI and albuminuria in a Dutch population. Other studies (22–30) supported this association, but most relevant to this study, two US cohort studies evaluated the association of BMI and albuminuria in younger adult populations: The Coronary Artery Risk Development in Young Adults (CARDIA) study (24) and the Bogalusa Heart Study (25). In the CARDIA study, subjects aged 18 to 30 yr were enrolled; albuminuria was measured at 10 and 15 yr and found in 6.3 and 6.7% of participants, respectively. A U-shaped relation was observed between quartiles of BMI measured at year 10 and albumin excretion, independent of BP and fasting glucose. The Bogalusa study enrolled subjects aged 5 to 17 yr and found a 4.7% prevalence of albuminuria at 16 yr of follow-up. Childhood BMI was not associated with adult albuminuria, whereas the relationship of adult BMI and albuminuria was not reported. One limitation of these two cohort studies is that participants were enrolled in the 1970s and 1980s, well before the dramatic increase in obesity in the US population that our study captures.

In this study, change in BMI over 6 yr but not baseline BMI was associated with albuminuria at follow-up, suggesting that growth in body mass may occur faster than the kidneys can adapt. Only one other study evaluated the relationship of change in BMI with kidney function using data from the Physicians Health Study, which is not directly comparable because of the older age of their cohort and use of a GFR-based measure of CKD (31). Nevertheless, our results are consistent with theirs, because they found that an increase in BMI >10% over 14 yr was associated with a 27% increased risk for CKD. Other studies were cross-sectional or evaluated a single measurement of baseline BMI or obesity (7,8,32).

Obesity-related glomerulopathy has been well described, with damage to the kidney suspected through a combination of hyperfiltration, high protein and salt intake, hypertension, hyperinsulinemia, and increased tubuloglomerular feedback as a result of increased sodium reabsorption, dyslipidemia, inflammation, and elevated leptin levels (33–35). A frequent complication of obesity-associated glomerulopathy is secondary FSGS (34). Renal biopsy diagnosis of obesity-related glomerulopathy, which often manifests clinically as albuminuria, has increased 10-fold in 15 yr, with a trend for more frequent diagnosis among men than women (1.6:1) compared with primary FSGS (1:1; $P = 0.09$) (34). This result in conjunction with our finding of an association of high BMI and albuminuria in men suggests that there may be an absolute body size, not just a proportional mass, that stresses the capacity of the kidney.

Urinalysis estimates from our study are important because few studies have reported these findings among young adults (36), with most evaluations among children (37–39) or older adults (40–43). The 4.6% prevalence of hematuria in our study is generally higher than reports of 0.5 to 4.1% in pediatric and adolescent studies (37–39), well above the 1.7% among young adults (mean age 21.8 yr) who were screened in the United Kingdom (44) yet similar to adult prevalence reports (42,43).

Table 2. Sex-specific albuminuria in Add Health Wave III study respondents ($n = 4463$)^a

Characteristic	Albuminuria ($n = 194$)	No Albuminuria ($n = 4269$)	<i>P</i>
Age (yr; mean \pm SEM)	21.6 \pm 0.2	21.7 \pm 0.1	0.86
Male (% [SE])	67 (4.7)	63 (1.0)	0.43
Ethnicity (% [SE])	68.5 (5.3)	72.1 (2.7)	0.32 ^d
white			
black	17.0 (4.0)	12.6 (1.7)	
Hispanic	12.9 (4.1)	10.8 (1.5)	
Asian	1.2 (0.7)	3.5 (0.9)	
Native American	0.4 (0.4)	1.0 (0.4)	
Education \leq 12 yr (% [SE])	45.3 (5.3)	46.3 (2.1)	0.84
BMI \geq 95th percentile at Wave I (% [SE])	27.1 (6.0)	19.2 (1.1)	0.22
BMI (kg/m ²)	29.4 \pm 0.6	28.3 \pm 0.2	0.01
BMI category (kg/m ² ; % [SE])			
<25	31.4 (4.9)	35.9 (1.2)	0.10 ^e
25 to <30	31.1 (4.9)	31.7 (1.0)	
30 to <35	13.9 (3.2)	18.0 (0.9)	
\geq 35	23.6 (4.1)	14.4 (0.9)	
Health insurance (yes; % [SE])	71.2 (4.0)	74.3 (1.2)	0.45
Condition (yes; % [SE]) ^b			
diabetes	2.8 (1.9)	0.9 (0.2)	0.32
glycosuria	4.7 (2.3)	1.1 (0.2)	0.15
diabetes and/or glycosuria	5.9 (2.5)	1.8 (0.3)	0.18
hypertension	9.8 (3.6)	6.2 (0.5)	0.33
Exercise (yes; % [SE])			
\geq 2 times/wk	48.5 (4.9)	53.0 (1.1)	0.36
heavy exercise \geq 2 times/wk	37.0 (4.7)	36.6 (1.1)	0.93
Smoking (yes; % [SE]) ^c	67.2 (6.6)	64.7 (1.5)	0.70

^aAlbuminuria \geq 17 in men and \geq 25 mg/g in women. Weighted to reflect the civilian noninstitutionalized population of the United States.

^bHypertension and diabetes history were by self-report.

^cSmoked in the past 30 d.

^d*P* value was calculated comparing Hispanic and black individuals with all others (white, Asian, and Native American). Other race/ethnicity groupings resulted in similar *P* values.

^e*P* value for overall association.

Proteinuria (>30 mg/dl) in the absence of leukocyturia and hematuria among 0.5% in our study is consistent with pediatric and adolescent studies (37–39), as well as with adult studies (42,43). Our finding of dipstick proteinuria (\geq 30 mg/dl) in just 11.9% of those with albuminuria highlights the danger of relying solely on dipstick measures, which, unlike albumin-to-creatinine ratio, do not take urine concentration into account. Glycosuria among 1.5% in this study, considerably higher than in other studies (43,44), is likely related to the high frequency of overweight and obesity that is, in turn, associated with more frequent and often undiagnosed diabetes.

This study has several strengths. We used a sample drawn from the general US population of young adults. The large sample size of >4000 young adults, although not the full Add Health cohort, had sufficient statistical power to study the relationship between albuminuria and obesity, with statistical differences in class II or greater obesity (\geq 35 kg/m²) detected between those with and without albuminuria. However, it should be noted that sample

weighting adjustments specifically based on urinalysis exclusion criteria were not used in the analysis, so caution should be used in making inferences to the general US population of young adults. Another strength is that the Add Health study population is composed of an understudied young adult population, with a mean age of 21.7 yr. This group represents the ideal target for primary prevention of CKD. Our study also included Hispanic individuals, another understudied population in which advanced kidney disease is becoming more prevalent (45,46). Disparities faced by racial and ethnic minorities in the United States may take decades to develop, which could explain the lack of association between race/ethnicity and albuminuria (47). Nevertheless, the association between high BMI and albuminuria was highest among black men.

There are several limitations to our study. Definitive kidney disease cannot be assessed using a single urine specimen, which may be subject to random variation and transient proteinuria from prolonged standing or exercise (48); however,

Table 3. Univariate and multivariate predictors of albuminuria in Add Health Wave III study respondents ($n = 4463$)^a

Characteristic	Univariate		Multivariate	
	OR (95% CI)	<i>P</i>	OR (95% CI) ^b	<i>P</i>
Age (yr)	1.01 (0.90 to 1.13)	0.86	0.99 (0.88 to 1.12)	0.91
Male <i>versus</i> female	1.19 (0.77 to 1.83)	0.43	1.24 (0.79 to 1.94)	0.35
Black <i>versus</i> others ^c	1.48 (0.91 to 2.40)	0.12	1.48 (0.89 to 2.44)	0.13
Hispanic <i>versus</i> others ^c	1.31 (0.66 to 2.58)	0.43	1.29 (0.65 to 2.58)	0.47
Education ≤ 12 yr (<i>versus</i> >12 yr)	0.96 (0.66 to 1.41)	0.84	0.87 (0.58 to 1.30)	0.48
BMI ≥ 95 th percentile at Wave I	1.56 (0.84 to 2.90)	0.15	1.54 (0.85 to 2.80)	0.16
BMI categories (<i>versus</i> BMI <25 kg/m ²) ^d				
25 to <30	1.12 (0.65 to 1.95)	0.68	1.07 (0.61 to 1.87)	0.81
30 to <35	0.88 (0.48 to 1.64)	0.69	0.83 (0.45 to 1.55)	0.56
≥ 35	1.87 (1.09 to 3.21)	0.02	1.76 (1.02 to 3.04)	0.04
Change in BMI from Wave I to Wave III (per unit change)	1.07 (1.01 to 1.13)	0.04	1.07 (1.00 to 1.13)	0.04
Health insurance (yes <i>versus</i> no)	0.86 (0.59 to 1.25)	0.43	0.91 (0.64 to 1.31)	0.63
Condition ^e				
diabetes (yes <i>versus</i> no)	3.12 (0.75 to 13.0)	0.12	1.93 (0.55 to 6.78)	0.30
glycosuria (yes <i>versus</i> no)	4.28 (1.42 to 13.0)	0.01	4.04 (1.47 to 11.1)	0.0097
diabetes and/or glycosuria	3.31 (1.28 to 8.53)	0.01	1.63 (0.37 to 7.24)	0.52
hypertension (yes <i>versus</i> no)	1.63 (0.72 to 3.66)	0.24	1.48 (0.63 to 3.48)	0.37
Exercise				
≥ 2 times/wk (<i>versus</i> <2)	0.83 (0.56 to 1.23)	0.36	0.81 (0.55 to 1.19)	0.28
heavy exercise ≥ 2 (<i>versus</i> <2) times/wk	1.02 (0.69 to 1.50)	0.93	1.04 (0.70 to 1.56)	0.83
Smoked in the past 30 d (<i>versus</i> no)	1.12 (0.62 to 2.04)	0.70	1.20 (0.64 to 2.28)	0.57

^aOR, odds ratio.

^bOR are reported using a base model with sex, ethnicity, BMI, and glycosuria. OR for additional covariates were calculated adding one at a time to the base model with sex, ethnicity, BMI, and glycosuria.

^cOthers are white, Native American, and Asian.

^dWhen controlling for BMI as a continuous variable, categorized BMI was excluded.

^eHypertension and diabetes history were by self-report. Diabetes and combined diabetes and/or glycosuria were not adjusted for glycosuria.

single-measure albuminuria does reflect a chronic condition in 63% of the general population (30). Urine was collected at any time during the day, whereas first-morning midstream urine may be preferred for albuminuria assessment and urinalysis (19,42). Urinary measures were evaluated only at the Wave III study visit, precluding assessment of incident cases of albuminuria. This study also lacked many clinical attributes, such as measured blood pressure, serum creatinine, and medication use; however, self-reported hypertension and diabetes were available, and measured glycosuria may indicate undiagnosed or undertreated diabetes. Two studies in adult populations (mean ages of approximately 50) suggested that obesity as a risk factor for albuminuria and CKD may be confounded by larger waist circumference (49) and that waist-to-hip ratio may provide additional information on risk (50). Unfortunately, these measurements were not available for this study. Also, changes in BMI for people who cross from adolescence into young adulthood are difficult to assess because different standards are used for these ages; however, a recent study (51) suggested that among adolescents, change in actual BMI works better than change in standardized BMI *z* score for longitudinal studies.

Despite these limitations, this study represents a large sample of young adults in the United States, and the finding of albuminuria associated with obesity is particularly concerning. Primary preventive strategies are needed to stem rising rates of CKD, and obesity is a potential target. If there is in fact a causal link between obesity and kidney disease, then rising obesity prevalence portends a continuing rise in kidney disease rates in the United States.

The guidelines from the National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (KDOQI) recommend screening for albuminuria among people who are at risk for kidney disease, including those with established diabetes or hypertension, other systemic illnesses, family history of kidney disease, and age >60 yr (10). Obesity may be a novel candidate screening criterion. A prospective study of the relationship between obesity and early markers of kidney damage in young adults is warranted.

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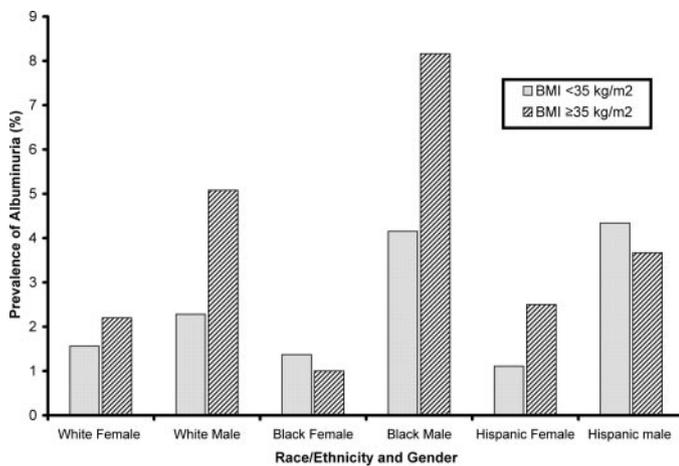


Figure 2. Prevalence of albuminuria (unadjusted) by class II obesity (body mass index [BMI] ≥ 35 kg/m²) versus all others (BMI <35 kg/m²) by race/ethnicity and sex groups.

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