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Lifestyle-Related Factors, Obesity, and Incident Microalbuminuria: The CARDIA (Coronary Artery Risk Development in Young Adults) Study

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Abstract

Background—Modifiable lifestyle-related factors are associated with risk of coronary heart disease and may also influence kidney disease risk.

Study Design—Community-based prospective cohort study.

Setting & Participants—2354 African-American and white participants ages 28–40 years, without baseline microalbuminuria or estimated glomerular filtration rate <60 ml/min/1.73 m^2 recruited from four U.S. centers: Birmingham AL, Chicago IL, Minneapolis MN, and Oakland CA.

Factors—Current smoking, physical activity, fast food habits, obesity, and diet quality, which was based on 8 fundamental components of the Dietary Approaches to Stop Hypertension (DASH) diet, including increased intake of fruits, vegetables, low-fat dairy products, whole grains, nuts and legumes, and reduced intake of sodium, sugar sweetened beverages, and red and processed meats.

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Outcomes & Measurements—Spot urine albumin-creatinine ratios (ACRs) were obtained at baseline (1995–96) and 3 5-year follow-up examinations (5, 10, and 15 years follow-up). Incident microalbuminuria was defined as presence of race and sex-adjusted ACR ≥25 mg/g at 2 or more of the successive follow-up examinations.

Results—Over the 15-year follow-up period, 77 individuals (3.3%) developed incident microalbuminuria. After multivariable adjustment, poor diet quality (OR, 2.0; 95% CI, 1.1–3.4) and obesity (OR, 1.9; 95% CI, 1.1–3.3) were significantly associated with microalbuminuria; current smoking (OR, 1.6; 95% CI, 0.9–2.8) was associated with microalbuminuria although the CI crossed 1.0. Neither low physical activity (OR, 1.0; 95% CI, 0.5–1.8) nor fast food consumption (OR, 1.2; 95% CI, 0.7–2.3) were associated with microalbuminuria. Compared to individuals with no unhealthy lifestyle-related factors (poor diet quality, current smoking and obesity), adjusted odds of incident microalbuminuria were 131%, 273%, and 634% higher for presence of 1 (OR, 2.3; 95% CI, 1.3–4.3), 2 (OR, 3.7; 95% CI, 1.8–7.7), and 3 (OR, 7.3; 95% CI, 2.1–26.1) unhealthy lifestyle-related factors.

Limitations—Self-reported dietary history and physical activity, low number of outcomes.

Conclusions—Consuming an unhealthy diet and obesity are associated with incident microalbuminuria.

Persistent microalbuminuria indicates presence of chronic kidney disease (CKD) regardless of the glomerular filtration rate and is associated with a heightened risk of cardiovascular events and kidney disease progression. [1–7] Based on estimates from the 1999–2004 National Health and Nutrition Examination Survey (NHANES), microalbuminuria accounts for the vast majority of CKD among young adults (<40 years of age), and its prevalence appears to be increasing. [8] A healthy lifestyle decreases the risk for cardiovascular and all-cause mortality [9,10]. However, the benefits of lifestyle behaviors on kidney disease risk remain poorly quantified. It is known that obesity, the cumulative result of excessive caloric intake relative to energy expenditure, substantially heightens risk of end-stage kidney disease (ESKD). [11–17] However, few studies have investigated the link between lifestyle-related factors including physical activity and dietary quality along with obesity on CKD risk. One study examining diet and incident CKD found that a Western dietary pattern (higher intake of red and processed meats, saturated fats, and sweets) is associated with rapid (≥ 3 ml/min/ 1.73 m^2) decline of estimated glomerular filtration rate (eGFR) and with microalbuminuria. [18]

The Dietary Approaches to Stop Hypertension (DASH) diet is high in fruits and vegetables, moderate in low-fat dairy, low in animal protein with a substantial amount of protein derived from nuts and legumes. [19] In combination with sodium restriction, the DASH diet has been shown to lower systolic blood pressure by as much as 11.5 mmHg and 7.1 mmHg in adults with and without hypertension, respectively. [19] Considering its substantial effect on blood pressure, this type of dietary pattern may have further benefits in decreasing the risk of microalbuminuria. Other lifestyle-related factors such as fast food consumption and smoking may also impact CKD risk. Fast food consumption leads to weight gain and insulin resistance in young adults [20] but has not been studied as a risk factor for microalbuminuria, whereas current smoking has been found to be associated with albuminuria in several studies. [14–17]

We examined the association between dietary quality, assessed as adherence to a DASH-type diet, fast food consumption, physical activity, smoking behaviors as well as baseline obesity status and incident microalbuminuria over a 15-year period among participants of the Coronary Artery Risk Development in Young Adults (CARDIA) Study. We hypothesized that unhealthy lifestyle-related factors and obesity status heighten risk of incident microalbuminuria in young healthy adults. We also examined whether overall lifestyle, measured as number of unhealthy lifestyle-related factors, is associated with incident microalbuminuria. Identifying modifiable lifestyle-related factors that increase risk for microalbuminuria may facilitate the development of primary prevention programs for early stages of kidney disease which may then delay or prevent end-stage kidney disease. [21]

METHODS

Study Population

CARDIA is a longitudinal study of cardiovascular disease risk factors in a US cohort of 5115 young African-American and white adults ages 18–30 years who were recruited during years 1985–1986 from four U.S. centers: Birmingham AL, Chicago IL, Minneapolis MN, and Oakland CA. Detailed methods for the CARDIA study have been previously published. [22] The year 10 exam (1995–1996) was used as the baseline year for this analysis as it was the first exam in which urine albumin-creatinine ratio (ACR) was measured in the CARDIA study. Dietary information was not obtained at the year 10 examination, so dietary data from the year 7 examination was used in this study. Of the 3505 CARDIA participants who were examined at the year 10 timpoint, 3026 non-pregnant CARDIA participants completed the year 7 and year 10 examinations and completed at least two follow-up examinations (years 15, 20, and 25) (Figure 1). We then excluded participants missing urine ACR data at year 10 (n=313) or other covariates of interest (n=117), those who reported extreme energy intakes at year 7 (women: <600 or >6000 kcal/d; men: <800 or >8000 kcal/d; n=68), and one individual who underwent a sex change. In addition, we excluded individuals who reported a history of kidney disease (glomerulonephritis or kidney failure) at year 10 or at a prior examination (n=20) or sex and race-adjusted (as described below) urinary ACR ≥25 mg/g at year 10 (n=153). (26) A total of 2354 CARDIA participants were then included in the analyses. (Figure 2)

Kidney Disease Measures

Urine albumin and creatinine were measured at the year 10, 15, 20, and 25 examinations using a single, untimed spot urine sample. Albumin and creatinine were measured in year 10 at the Regional Kidney Disease Program Renal Laboratory, Hennepin County Medical Center, Minneapolis, Minnesota. Albumin was assessed using a nephelometric procedure with a specific anti-albumin monoclonal antibody, and the Jaffe method was used for creatinine. The year 15, 20, and 25 samples were analyzed at the Molecular Epidemiology and Biomarker Research Laboratory at the University of Minnesota (Minneapolis, MN), using a nephelometric procedure for albumin and the Jaffe method for creatinine. To account for sex and racial differences in creatinine excretion, we defined microalbuminuria based on the formula albumin/k × creatinine (denoted A/kC), where k = 0.68 if male and 0.88 if African-American (0.68*0.88 for African-American males). [23] Serum creatinine was measured by the Jaffe method, and eGFR was calculated using the creatinine-based CKD Epidemiology Collaboration (CKD-EPI) estimating equation for the baseline (year 10) examination. [24]

Lifestyle-Related Factors and Obesity

The lifestyle-related factors assessed included diet quality, fast food habits, physical activity, and smoking status. We also examined baseline obesity status as a risk factor in addition to the other lifestyle-related factors. While obesity may be in the causal pathway of low physical activity and poor diet to microalbuminuria, we included it in the analysis because it represents the individual's balance between caloric consumption compared to caloric expenditure. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared, and obesity was defined as a BMI ≥ 30 kg/m^2. [25] The CARDIA dietary history [26] queried usual dietary practices and obtained a food frequency of the past month at the year 7 examination. The reliability and validity of the interviewer-administered CARDIA dietary history have been previously reported with validity correlations generally above 0.50 comparing mean daily nutrient intakes from the CARDIA dietary history versus 7 randomly scheduled 24-hour recalls. [27]

Diet quality was based on 8 fundamental components of the DASH diet including increased intake of fruits, vegetables, low-fat dairy products, whole grains, nuts and legumes, and reduced intake of sodium, sugar sweetened beverages, and red and processed meats. [19] Sugar sweetened beverages included fruit drinks, sweetened soft drinks, and sweetened water. For each of the components, we classified participants into quartiles according to their intake ranking. For the 5 categories of fruits, vegetables, nuts and legumes, low-fat dairy products, and whole grains, we assigned a score between 1 (worst) for the lowest quartile and 4 (best) for the highest quartile, based on the individual's intake ranking among all CARDIA participants. For the 3 categories of sodium, red and processed meats, and sugar-sweetened beverages, the lowest quartile was given a score of 4 points and the highest quartile a score of 1 point. Sodium intake was not directly assessed in CARDIA and we did not include added table and cooking salt; however, since the majority of sodium in the American diet is derived from processed foods [28], the CARDIA diet history provides a reasonably standardized estimate sufficient to classify greater versus lesser intake of these processed foods. The scores for each diet component were summed to obtain an overall DASH-type diet score ranging from 8 (least healthy) to 32 (most healthy). We then divided the participants into quintiles based on their overall DASH-type diet score, and people with an overall diet score in the lowest quintile were considered as having the least healthy diet. Due to the above concerns regarding sodium intake estimation, we also constructed a modified DASH-type diet score excluding sodium intake as one of the categories.

Fast food habits during the baseline (year 10) examination were quantified based on responses to the question: "How often do you eat breakfast, lunch, or dinner at places such as McDonald's, Burger King, Wendy's, Arby's, Pizza Hut, or Kentucky Fried Chicken?" Frequent fast food consumption was defined as eating fast food visits ≥ 3 times/week, which was the highest quintile of the number of times per week among participants reported consuming fast food. The physical activity questionnaire queried the amount of time per week spent in leisure, occupational, and household physical activities over the past 12 months. [22,29] Total physical activity was estimated in exercise units as a product of intensity×frequency; since duration of activity was not queried, the more conventional assessment in metabolic equivalents was not available. Because physical activity varied strongly by sex, sex-specific quartiles of activity scores at the baseline examination were calculated. Low physical activity was defined as a physical activity score in the lowest gender-specific quintile. Body weight was measured to the nearest 0.2 kg with a calibrated balance beam scale, and height was measured with a vertical ruler to the nearest 0.5 cm. Smoking status was determined by self-report and dichotomized as currently smoking or not currently smoking.

Covariates

At each examination, three blood pressure measurements were taken by centrally trained staff using sphygmomanometry and the mean of the last two measurements was calculated. At each examination, hypertension was defined as a systolic blood pressure ≥140 mmHg or a diastolic blood pressure ≥ 90 mmHg or the self-reported use of antihypertensive medications. Blood was collected at each study visit and stored at −70°C until measurements were performed. Fasting glucose was measured using a standard laboratory technique. At each examination, diabetes was defined as fasting blood glucose ≥ 126 mg/dl or use of diabetes medications.

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Statistical Analysis

The primary outcome of interest was incident microalbuminuria, which was defined as sex and race-adjusted urine ACR ≥ 25 mg/g at two separate time points (year 15, year 20, or year 25 exam) due to the high intra-individual variability of spot urine ACR [30]. The lifestyle-related factors and baseline obesity status were dichotomized and logistic regression was used to examine the association of each unhealthy lifestyle-related factor and baseline obesity with incident microalbuminuria adjusted for covariates, chosen a priori, including age, sex, race, family history of kidney disease, education level, and baseline ACR. The model including diet quality was additionally adjusted for total energy intake. Multivariable model 1 includes all lifestyle-related factors and obesity adjusted for the same covariates and total energy intake. We then explored whether diabetes or hypertension attenuated the association between unhealthy lifestyle-related factors and incident microalbuminuria by adding these covariates (at year 10) to multivariable model 2.

A secondary analysis was conducted using logistic regression to examine the association between the number of unhealthy lifestyle-related factors and incident microalbuminuria while adjusting for age, sex, race, family history of kidney disease, education level, baseline ACR, and energy intake. We included only 3 unhealthy lifestyle-related factors (current smoking, poor diet quality, and obesity) in this model post-hoc based on their effect sizes and p values. A χ^2 test for trend was used to determine significant linear trends in odds of incident microalbuminuria across the number of unhealthy lifestyle-related factors present compared to presence of no unhealthy lifestyle-related factors. All analyses were conducted using SAS statistical software (version 9.2; SAS Institute Inc; Cary, Indiana).

RESULTS

CARDIA participants who were excluded from this analysis were more likely to be African-American, younger, less educated, current smokers, and have higher ACR levels than participants in the study sample. Characteristics of participants stratified by diet quality (lowest quintile of DASH score compared to the upper 4 quintiles) are shown in Table 1. Among a total of 2354 participants included in the analysis, 77 (3.3%) developed incident microalbuminuria. Individuals who developed incident microalbuminuria were more likely to be male, African-American, current smokers, hypertensive, diabetic, and have a family history of kidney disease compared to those without incident microalbuminuria. Individuals who developed microalbuminuria consumed less fruit and low-fat dairy, but consumed more sugar-sweetened beverages and red and processed meat than individuals who did not develop microalbuminuria. (Table 2). Those who developed microalbuminuria were more likely to be obese, current smokers, eat a poor-quality diet (lowest quintile of DASH-type diet score), and consume more fast food compared to individuals who did not develop microalbuminuria (Table 3). Only 1.4% of individuals with no unhealthy lifestyle-related factors (including only obesity, current smoking, and poor diet quality) developed microalbuminuria. In comparison 4.5%, 7.5%, and 12.5% of individuals with 1, 2, and 3 unhealthy lifestyle-related factors developed microalbuminuria.

After adjustment for age, sex, race, family history of kidney disease, education and baseline ACR, both obesity (odds ratio [OR], 2.2; 95% confidence interval [CI], 1.3–3.7) and poor diet quality (OR, 2.1; 95% CI, 1.2–3.5) were significantly associated with incident microalbuminuria (Table 4). Current smoking was associated with higher odds of incident microalbuminuria (OR, 1.5; 95% CI, 0.9–2.6) after adjustment for covariates although the confidence interval included 1.0. Low physical activity (OR, 1.1; 95% CI, 0.6–1.8) and frequent fast food consumption (OR, 1.4; 95% CI, 0.7–2.5) were not significantly associated with incident microalbuminuria. (Table 4) When all unhealthy lifestyle-related factors and baseline obesity were included in multivariable model 1, results were similar, with obesity

(OR, 2.2; 95% CI, 1.3–3.8) and poor diet quality (OR, 1.9; 95% CI, 1.1–3.3) remaining significantly associated with incident microalbuminuria. Current smoking was again associated with incident microalbuminuria (OR, 1.5; 95% CI, 0.9–2.7) although this was not statistically significant (P=0.1). No associations between frequent fast food consumption or low physical activity and incident microalbuminuria were observed. (Table 4) Adjustment for baseline hypertension and diabetes slightly attenuated the association between obesity and incident microalbuminuria (OR, 1.9; 95% CI, 1.1–3.3), but had little effect on associations with other lifestyle-related factors. (Table 4) Findings were similar when we utilized a modified DASH-type diet score, which excluded sodium intake as one of the diet categories (data not shown).

Table 5 shows the ORs for incident microalbuminuria by the number of unhealthy lifestyle-related factors including current smoking, poor diet quality, and being obese after adjusting for age, gender, race, family history of kidney disease, and education. When compared to individuals with 0 unhealthy lifestyle-related factors, those with 1 unhealthy lifestyle-related factor had increased risk (OR, 2.3; 95% CI, 1.3–4.3) of incident microalbuminuria. This risk was greater in those with 2 (OR, 3.7; 95% CI, 1.8–7.7) and 3 (OR, 7.3; 95% CI, 2.1–26.1) unhealthy lifestyle-related factors (p for trend <0.001).

DISCUSSION

In a large cohort of young adults, poor diet quality as defined by a low DASH-type diet score and obesity were significantly associated with incident microalbuminuria over a 15-year period after adjustment for age, sex, family history of kidney disease, education, baseline hypertension and diabetes. We also found that overall unhealthy lifestyle, quantified as number of unhealthy lifestyle-related factors, was associated with incident microalbuminuria. Adhering to a healthy lifestyle has previously been found to be associated with decreased risk for cardiovascular and all-cause mortality. [9,10] Our findings suggest that an unhealthy lifestyle may heighten risk of early stages of kidney disease (microalbuminuria), a risk factor for progression to later CKD stages and cardiovascular disease. [1,2,4,5,7]

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Obesity and, to a lesser extent, current smoking have been associated with incident CKD and ESKD in numerous studies. [12,14–17] However, most studies defined CKD as an eGFR<60ml/min/1.73 m^2 without albuminuria or proteinuria measures. One large community-based study of 123,764 Japanese adults older than 40 years followed for 10 years reported that both obesity and smoking significantly increased the risk of proteinuria defined by a health screening urine dipstick protein ≥1+. [16] Smoking may lead to microalbuminuria through a number of mechanisms including endothelial dysfunction, oxidative stress, and hemodynamic changes. [31] Obesity may heighten risk for all CKD stages via increasing blood pressure and insulin resistance, or by altering glomerular hemodynamics and adipocyte-derived bioactive molecules such as leptin or adiponectin [32–35]. As first described in the 1970s, a minority of obese individuals develop substantial proteinuria with biopsy findings of glomerulomegaly, usually with focal segmental glomerulosclerosis and foot process fusion. [36]

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This study suggests that, beyond calories, diet quality independently affects CKD risk, because poor diet quality was significantly associated with incident microalbuminuria even after adjusting for other lifestyle-related factors and obesity. Lin studied associations between dietary patterns and kidney function decline in the Nurses' Health Study, and reported that a DASH-type diet was associated with decreased risk of rapid eGFR decline and incident microalbuminuria when adjusted for age and total energy intake. However, after multivariable adjustment, only the association with rapid eGFR decline remained

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significant. [18] A secondary analysis of the DASH study showed that among individuals with pre-hypertension or hypertension, a diet high in fruits and vegetables decreased urinary albumin excretion in those with urinary albumin excretion >7 mg/24 h, a finding not explained by blood pressure, total protein or sodium intake. [37]

Other short-term feeding trials have shown that diets high in animal protein result in higher urinary albumin excretion and renal vasodilatation compared to equivalent diets with vegetable protein. [38,39] Our study noted a higher intake of red and processed meat among individuals who developed microalbuminuria, a finding similar to a previous study. [40] Protein derived from vegetable sources may include beneficial antioxidants such as isoflavones, which may alleviate endothelial dysfunction and reduce albuminuria. [39] However, not all feeding studies have shown similar results [41], and the long-term consequences of dietary changes on albuminuria require further study.

While we did not find an association between physical activity and incident microalbuminuria in our study, inaccuracy of self-report of physical activity may have limited our ability to detect an association. Some but not all studies have reported low physical activity to be associated with various kidney disease measures including albuminuria. [42–44] A small non-randomized study in individuals with type 2 diabetes found that after 6 months of supervised aerobic exercise, microalbuminuria regressed in 5 of the 6 participants who had microalbuminuria at baseline. [45] However, BMI significantly decreased during the study, and the observed decrease in albuminuria may have been due to weight loss. Regardless, maintaining a healthy lifestyle through physical activity and eating prudently may be beneficial in preventing microalbuminuria.

The strengths of this study include the relatively young age of participants at baseline, the long duration (15 years) of follow-up, standardized, validated diet assessment measures, and repeated ACR measurements. However, the current study has several potential limitations. Dietary data was derived from the year 7 examination as no data was available from year 10, and lifestyle-related factors may have changed during the course of the study. It is important to emphasize that the DASH diet comes from carefully controlled feeding trials in which the participants had very high adherence to the diet. [19] The DASH-type diet score used in this study quantified agreement between self-reported diet with DASH guidelines rather than the DASH diet initially established in clinical trials. [19] Other dietary scores are available to quantify the healthiness of an individual’s diet. [46] We used a diet score that incorporated information on self-reported intake of food groups rather than nutrient intake, similar to other diet scores based on the DASH guidelines used in previous studies examining dietary patterns and kidney disease risk. [47]

Several factors likely biased our findings towards the null. First, individuals who were excluded or missing data were more likely to be current smokers, less educated, and have higher ACR levels; moreover, a few individuals had microalbuminuria at year 15 but died prior to another follow-up examination, so would not have been included in our analysis. Dietary history was self-reported and subject to non-differential misclassification which likely weakened the strength of association between diet quality and incident microalbuminuria. We did not have 24-hour urinary sodium collections in this study and did not find an association between estimated dietary sodium intake and albuminuria in interim analyses (data not shown). The lack of associations between sodium intake, frequent fast food consumption, physical activity and microalbuminuria may have been due to misclassification and/or changes in these habits over time. [20]

While we adjusted for other lifestyle-related factors such as current smoking and physical activity, diet is paralleled by other lifestyle and environmental factors that we may not have been able to account for in our study. This study focused solely on microalbuminuria becasue this accounts for the majority of CKD in this age group. There were only 3 individuals in our study population who developed eGFR <60ml/min/1.73m^2 but not microalbuminuria (at two follow-up visits per our stringent definition); thus, we chose to include only incident microalbuminuria as our outcome. Future studies should evaluate associations between lifestyle-related factors and other kidney disease measures such as eGFR decline. As is the case for any observational study, our findings do not prove causality, and clinical trials will be needed to assess the impact of lifestyle modifications on CKD risk.

In this study of young adults, obesity, current smoking, and eating a poor quality diet were associated with incident microalbuminuria. Future studies should focus on interventions which enhance adherence to a DASH–type diet, reduce weight and encourage smoking cessation for prevention of microalbuminuria.

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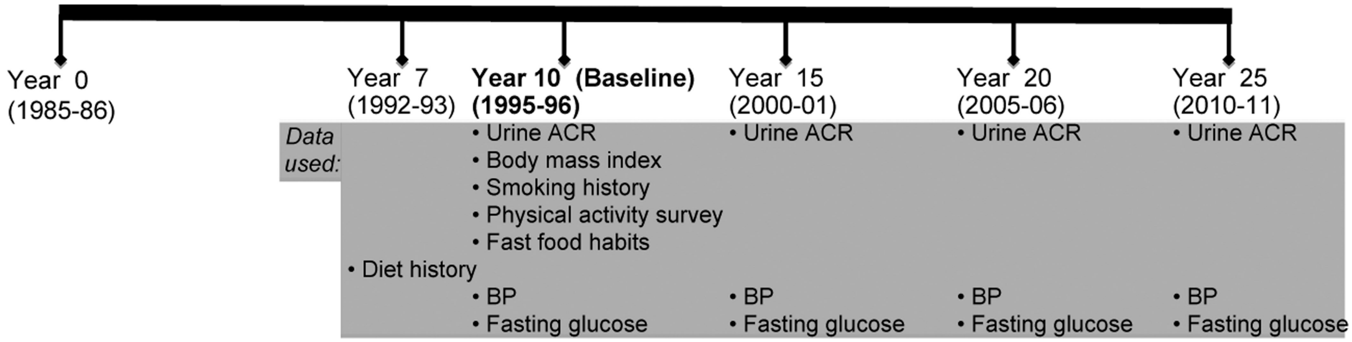

Figure 1. Timeline

Abbreviations: ACR (albumin-creatinine ratio), BP (blood pressure)

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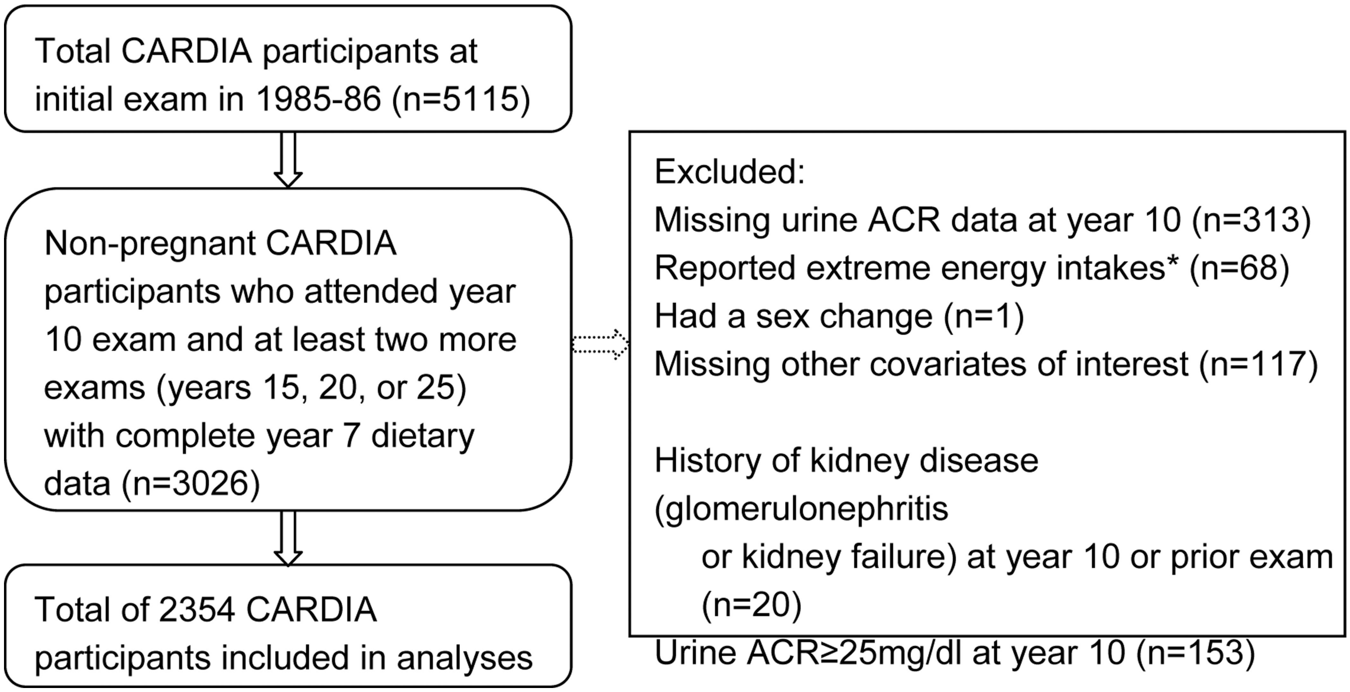

Figure 2. Flowchart

Abbreviations: ACR (albumin-creatinine ratio) CARDIA, Coronary Artery Risk Development in Young Adults

*Extreme energy intakes defined as <600 or >6000 kcal/day for women and <800 or >8000 kcal/day for men.

Table 1

Characteristics of CARDIA Participants at Year-10 Study Visit by DASH Diet Score

	Unhealthy Diet*# (n=463)	**DASH Score Quintiles 2–5# (n=1891)**	**P value**
Age (y)	34.2 ±3.9	35.4 ±3.4	<0.001
Male sex	48.4	46.3	0.4
African-American	65.7	35.2	<0.001
Formal education (y)	14.6 ± 2.5	16.0 ±2.5	<0.001
Family History of kidney disease	12.7	9.0	0.02
BMI (kg/m^2)	28.0 ± 6.2	26.8 ±5.7	<0.001
Waist circumference (cm)	87.8 ±14.0	84.5 ± 13.3	<0.001
Current smoking	29.2	19.2	<0.001
SBP (mmHg)	110.6 ±12.0	108.6 ±11.5	0.001
DBP (mmHg)	73.4 ± 9.5	71.5 ± 9.4	<0.001
Hypertension	9.1	5.3	0.002
Diabetes	1.1	2.0	0.2
Fasting glucose (mg/dl)	91.4 ± 14.2	90.3 ±12.5	0.1
Total cholesterol (mg/dl)	176.6 ± 33.6	178.6 ± 33.4	0.3
HDL cholesterol (mg/dl)	49.9 ±13.4	50.1 ±13.5	0.8
Urine ACR (mg/g)			
Women	4.7 [3.4–6.9]	4.2 [2.9–6.5]	0.01
Men	5.8 [4.2–8.8]	5.2 [3.8–7.2]	0.004
eGFR (ml/min/1.73m^2)	101.7 ±14.6	101.3 ± 13.8	0.6
Total energy intake (kcal/d)			
Women	1867.2 [1421.7–2531.6]	2207.4 [1731.0–2779.9]	<0.001
Men	2691.6 [2100.7–3634.8]	3066.8 [2316.5–4024.6]	<0.001
Physical activity score (exercise units)			
Women	142.0 [58.0–261.0]	232.0 [112.0–404.0]	<0.001
Men	304.0 [156.0–460.0]	397.0 [218.5–604.5]	<0.001
Weekly Fast food visits	2.0 [0.7–4.0]	0.9 [0.2 to 2.0]	<0.001

Note: Values for categorical variables are given as percentages; values for continuous variables are given as mean ± standard deviation or median [interquartile range]. Conversion factors for units: cholesterol in mg/dL to mmol/L, x0.02586; glucose in mg/dL to mmol/L, x0.05551.

*Lowest DASH score quintile.

#Dietary data from year 7 was used as no dietary data was collected during the baseline (year 10) examination. The DASH score was based on the DASH diet including 8 key components: high intake of fruits, vegetables, low-fat dairy products, nuts, and whole grains and low intake of sodium, sugar-sweetened beverages, and red and processed meats.

Abbreviations: BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; HDL, high-density lipoprotein; ACR, albumin-creatinine ratio; eGFR, estimated glomerular filtration rate. DASH, Dietary Approaches to Stop Hypertension; CARDIA, Coronary Artery Risk Development in Young Adults

Table 2

Dietary Characteristics at Year 7 by Subsequent Incident Microalbuminuria Status

DASH Score Components and Total Energy Intake	Microalbuminuria (n=77)	No Microalbuminuria (n=2277)	P value
Fruits (servings/d)	0.9 (0.3 – 2.0)	1.2 (0.6 – 2.2)	0.05
Vegetables (servings/d)	3.3 (2.1 – 4.5)	2.9 (1.8 – 4.5)	0.3
Whole grains(servings/d)	1.4 (0.6 – 2.3)	1.5 (0.7 – 2.7)	0.2
Nuts and legumes (servings/d)	0.8 (0.2 – 1.4)	0.7 (0.3 – 1.8)	0.5
Low-fat dairy (servings/d)	0.5 (0.2 – 1.2)	0.9 (0.3 – 1.9)	0.02
Sugar-sweetened beverages (servings/d)	1.2 (0.3 – 2.3)	0.6 (0.1 – 1.6)	0.004
Red and processed meat (servings /d)	3.6 (2.4 – 5.6)	2.4 (1.4 – 4.0)	<0.001
Sodium (mg/1000 cal/d)	1565.2 (1386.4 – 1771.8)	1545.1 (1355.8 – 1739.5)	0.7
Total energy intake (kcal/d)	3210.1 (1442.4)	2714.2 (1171.7)	0.01

Note: Dietary data from year 7 was used as no dietary data was collected during the baseline (year-10) examination. Values are presented as median [interquartile range], except for total energy intake which is given as mean ± standard deviation..

DASH, Dietary Approaches to Stop Hypertension; CARDIA, Coronary Artery Risk Development in Young Adults

Table 3

Baseline Unhealthy Lifestyle-Related Factors and Obesity Status by Subsequent Incident Microalbuminuria Status

	Microalbuminuria (n=77)	**No Microalbuminuria (n=2277)**	**P value**
Unhealthy Lifestyle-related Factors *			
Obesity	44.2	22.7	<0.001
Poor diet quality	36.4	19.1	<0.001
Current smoking	33.8	20.8	0.01
Fast food visits ≥3/wk	23.4	18.4	0.1
Low physical activity	20.8	14.8	0.3
No. of unhealthy lifestyle-related factors †			
0 (n=1193)	22.1	51.7	<0.001
1 (n=842)	46.7	35.4	0.04
2 (n=287)	26.0	11.7	<0.001
3 (n=32)	5.2	1.2	0.003

Note: Values are given as percentages.

*Included obesity (BMI≥30 kg/m^2), poor diet quality (lowest quintile of DASH-type diet score), current smoking, fast food visits ≥3 times/week (highest quintile of number of times per week among participants who reported consuming fast food), and low physical activity (lowest quintile of sex-specific physical activity score).

†Only included obesity, poor diet quality and current smoking as unhealthy lifestyle-related factors.

BMI, body mass index; DASH, Dietary Approaches to Stop Hypertension

Table 4

Odds of Incident Microalbuminuria by Presence of Unhealthy Lifestyle-Related Factors and Baseline Obesity

	Individual Models¶		Multivariable Model 1¶¶		Multivariable Model 2¶¶¶	
	OR (95% CI)	**P value**	**OR (95% CI)**	**P value**	**OR (95% CI)**	**P value**
Obesity	2.2 (1.3 – 3.7)	0.001	2.2 (1.3 – 3.8)	0.002	1.9 (1.1 – 3.3)	0.01
Poor diet quality	2.1 (1.2 – 3.5)	0.01	1.9 (1.1 – 3.3)	0.01	2.0 (1.1 – 3.4)	0.01
Current smoking	1.5 (0.9 – 2.6)	0.1	1.5 (0.9 – 2.7)	0.1	1.6 (0.9 – 2.8)	0.1
Fast food visits ≥ 3/wk	1.4 (0.7 – 2.5)	0.3	1.2 (0.6 – 2.2)	0.6	1.2 (0.7 – 2.3)	0.5
Low physical activity	1.1 (0.6 – 1.8)	0.9	1.0 (0.5 – 1.7)	0.9	1.0 (0.5 – 1.8)	0.9
Hypertension					1.7 (0.9 – 3.5)	0.1
Diabetes					4.0 (1.3 -12.0)	0.01

Note: Unhealthy lifestyle-related factors tested included obesity (BMI≥30 kg/m^2), poor diet quality (lowest quintile of DASH-type diet score), current smoking, fast food visits ≥3 times/week (highest quintile of number of times per week among participants who reported consuming fast food), and low physical activity (lowest quintile of sex-specific physical activity score).

¶Individual models for each unhealthy lifestyle-related factor adjusted for age, sex, race, family history of kidney disease, education, and baseline (year-10) ACR. The model including poor diet quality was also adjusted for total energy intake.

¶¶Multivariable model 1 includes all lifestyle-related factors including baseline obesity adjusted for age, sex, race, family history of kidney disease, education, total energy intake, and baseline (year-10) ACR.

¶¶¶Multivariable model 2 includes all variables in multivariable model 1 additionally adjusted for baseline (year-10) hypertension and diabetes.

ACR, albumin-creatinine ratio; BMI, body mass index; DASH, Dietary Approaches to Stop Hypertension; OR, odds ratio; CI, confidence interval

Table 5

Odds of Incident Microalbuminuria by Number of Unhealthy Lifestyle-Related Factors

	Base Model		+ HTN and DM ¶	
	OR (95% CI)	**P value**	**OR (95% CI)**	**P value**
No. of unhealthy lifestyle-related factors		<0.001 *		<0.001 *
0 (n=1193)	1.0 (referent)		1.0 (referent)	
1 (n=842)	2.3 (1.3–4.3)	0.01	2.0 (1.1–3.8)	0.03
2 (n=287)	3.7 (1.8–7.7)	<0.001	3.7 (1.8–7.6)	<0.001
3 (n=32)	7.3 (2.1–26.1)	0.002	5.1 (1.3–21.2)	0.02
Hypertension at baseline			1.7 (0.9–3.4)	0.1
Diabetes at baseline			4.1 (1.4–12.3)	0.01

Note: Unhealthy lifestyle-related factors selected in these multivariable models included obesity, poor diet quality (lowest quintile of DASH-type diet score), and current smoking adjusted for age, sex, race, family history of kidney disease, education, total energy intake, and baseline albumin-creatinine ratio.

¶Model adjusted for HTN and DM at the baseline (year-10) examination.

*P for linear trend

Abbreviations: HTN, hypertension; DM, diabetes mellitus DASH, Dietary Approaches to Stop Hypertension; OR, odds ratio; CI, confidence interval