Physical Activity Patterns and Kidney Function Changes Among Hispanic/Latino Adults: An Analysis from the HCHS/SOL Cohort

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A thesis

submitted in partial fulfillment of the

requirement for the degree of

Master of Public Health

University of Washington

2025

Committee:

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Program Authorized to Offer Degree:

Epidemiology

University of Washington

Abstract

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Background: Physical activity (PA) may be a modifiable factor for CKD prevention, but evidence specific to Hispanic/Latino populations is limited. **Objective:** To examine the association between PA patterns and longitudinal changes in kidney function among Hispanic/Latino adults. **Methods:** We conducted a secondary analysis of the Hispanic Community Health Study/Study of Latinos, a prospective cohort of 16,415 self-identified Hispanic/Latino adults aged 18–74 years, recruited from Chicago, Miami, the Bronx, and San Diego (2008–2011). Participants with complete accelerometer data, kidney function measurements at baseline and follow-up, and relevant covariate data were included. Of 8,073 participants in the main analysis, 7,177 were included in the incident CKD analyses after excluding those with baseline CKD. PA was assessed via 7-day accelerometry (light PA: 10–1534 counts/min; moderate-to-vigorous PA [MVPA]: ≥1535 counts/min) and self-reported measures using the Global Physical Activity Questionnaire, categorized as total MVPA and recreational MVPA. Primary outcomes were annual percent change in estimated glomerular filtration rate (eGFR) and annual change in urine albumin-to-creatinine ratio (UACR). The secondary outcome was incident CKD, defined as eGFR <60 mL/min/1.73 m^2 with >1 mL/min/year decline or UACR ≥30 mg/g at follow-up. **Results:** Among 8,073 participants (mean age 42.5 years; 55.7% women), the average annual percent change in eGFR was –0.61% (95% CI: –0.68% to –0.54%), and the average annual change in UACR was +2.03 mg/g (95% CI: 0.98 to 3.07). In fully adjusted models, accelerometer-measured light PA and MVPA were not significantly associated with eGFR change (light PA: –0.009% per 15 min/day; 95% CI: –0.024% to 0.006%; MVPA: –0.012% per 15 min/day; 95% CI: –0.046% to 0.023%). However, self-reported recreational MVPA was associated with significantly lower UACR (–0.208 mg/g per year per 15 min/day; 95% CI: –0.390 to –0.026). No significant associations were found between PA and incident CKD. **Conclusions:** Among Hispanic/Latino adults, higher recreational MVPA was associated with reduced albuminuria, suggesting potential kidney health benefits. However, no significant associations were observed between overall physical activity and kidney function decline or incident CKD. These findings highlight the need for further research to explore why recreational PA, but not total or accelerometer-measured PA, may be linked to kidney health in this population.

PHYSICAL ACTIVITY PATTERNS AND KIDNEY FUNCTION CHANGES AMONG HISPANIC/LATINO ADULTS: AN ANALYSIS FROM THE HCHS/SOL COHORT

INTRODUCTION

Chronic kidney disease (CKD) affects an estimated 674 million people worldwide and is projected to become the fifth leading cause of years of life lost by 2040, prompting calls for WHO to prioritize it among non-communicable diseases.[1] In the United States (U.S.), approximately 14% of the population has some degree of CKD.[2]

Evidence from several studies suggests that physical activity (PA) is a modifiable lifestyle factor that may help prevent the development of CKD and slow its progression[3–5], though it remains unclear whether all forms of PA provide equal benefits for kidney health across different populations. Meta-analyses suggest leisure-time PA may offer greater protection than total PA [5], but ethnicity-specific patterns, particularly in Hispanic/Latino populations, remain underexplored.

The Hispanic Community Health Study/Study of Latinos (HCHS/SOL), a diverse community-based cohort initiated in 2008, provides detailed accelerometer-measured and self-reported PA data alongside longitudinal kidney function measures, offering a robust platform for examining PA's effect on kidney health among U.S. Latino adults. This study brings attention to the Hispanic/Latino population in the U.S., where CKD is a significant and growing public health concern, with rising rates of advanced CKD and end-stage renal disease [6,7]. In this cohort, sedentary behavior has been linked to declining kidney function[8], while moderate-to-vigorous physical activity (MVPA) is associated with improved cardiometabolic health[9]. The type of PA—work-related, transportation-related, or recreational—is especially relevant for Latino adults, as work-related activity is more common in younger groups and often coincides with poorer adiposity measures.[10]

This study examines the association between PA patterns and changes in kidney function among Latino adults using HCHS/SOL cohort data, aiming to inform CKD prevention strategies in this population.

METHODS

Study design and population

The HCHS/SOL is a community-based prospective cohort study comprising 16,415 self-identified Hispanic/Latino individuals aged 18 to 74 years at screening. Participants were recruited from randomly selected households across four field centers in the U.S. (Chicago, IL; Miami, FL; Bronx, NY; and San Diego, CA).[11,12] The baseline examination (V1) was conducted from 2008 to 2011, and all participants were invited to attend a second comprehensive examination (V2) that was completed during 2014-2018.[10] Each of these examinations included standardized clinical measurements such as anthropometry, blood and urine laboratory tests, medication inventory, medical history, and questionnaires capturing lifestyle and social determinants of health.

Definition of main exposure variables relating to physical activity

Physical activity in the HCHS/SOL cohort was assessed using both wearable monitors and self-reported measures. At baseline, all participants were asked to wear an Actical accelerometer (model 198-0200-03; Respironics Co. Inc.) for 7 consecutive days to measure PA patterns. Self-reported PA data were collected through the Global Physical Activity Questionnaire (GPAQ) at baseline, from which we assessed total and recreational moderate-to-vigorous physical activity

(MVPA). Participants were considered adherent to the accelerometer protocol if they wore the device for at least 3 days for a minimum of 10 hours per day.[13]

We calculated the time of each intensity of accelerometer-measured PA by summing the minutes reported for each day and averaging across adherent days. We defined light PA as 10-1534 counts/min. MVPA was defined as equal to or more than 1535 counts/min. Light PA and MVPA were both assessed as continuous variables and as quartiles. Additionally, sedentary time was defined as less than 10 counts/min.[14]

For self-reported PA, we used data from the GPAQ at baseline, which included the assessment of self-reported total MVPA for a typical week conducted through a series of targeted questions. Participants reported their frequency of engagement (days per week, hours/minutes per day) across different domains: moderate or vigorous-intensity activities performed as part of work responsibilities; active transportation methods such as walking or bicycling to reach destinations; and moderate or vigorous-intensity sports, fitness or recreational activities during leisure time. Using time in activities estimated from the GPAQ, we categorized total MVPA according to the Physical Activity Guidelines for Americans 2018 (PAG 2018): Inactive (no moderate or vigorous activity beyond basic daily movements); Insufficiently active (some activity but less than 150 minutes moderate or 75 minutes vigorous weekly); Active (150-300 minutes of moderate or vigorous intensity activity weekly, meeting guidelines); and Highly active (more than 300 minutes of moderate/vigorous intensity activity weekly, exceeding guidelines).[15]

Definition of outcome variables related to kidney disease

To assess kidney function, blood samples were obtained during V1 and V2 to measure serum creatinine and serum cystatin levels, which we subsequently used to calculate eGFR using the 2021 CKD-Epidemiology Collaboration Creatinine-Cystatin C Equation. Concurrently, urine samples were collected during visits and analyzed for both albumin and creatinine concentrations, allowing for the determination of urine albumin-to-creatinine ratio (UACR). The specific laboratory methods are described elsewhere.[8,16]

To assess the association of PA with CKD, our primary outcomes were: 1) percent change in eGFR per year (calculated by subtracting the V2 eGFR from the V1 eGFR, dividing by the V1 eGFR, and dividing by the follow-up time in years), and 2) change in UACR per year (calculated by subtracting V1 UACR from V2 UACR and dividing by follow-up time in years).

Our secondary outcome was incident CKD, defined at V2 as eGFR less than 60 ml/min/1.73m² and a decline of more than 1 ml/min per year (estimated from the difference between V1 and V2 measurements) or V2 UACR equal to or greater than 30 mg/g, similarly as in a previous HCHS/SOL study.[16]

Covariates

To describe the population and control for confounders, we defined covariates based upon measurements at V1, with relevant characteristics chosen based on previous studies.[8,9,16] For our analysis, these covariates were classified and subsequently added to the models:

- **Demographics:** Age, gender, center, country of birth, Hispanic/Latino background, language preference, education, and income level.
- **Occupational characteristics:** Employment status, homemaker status, and current occupation.
- **Lifestyle:** Cigarette use, alcohol use risk level, AHEI 2010 score (diet), and sedentary time.
- **Clinical information and comorbidities:** BMI, waist-to-hip ratio, baseline eGFR, baseline UACR, C-reactive protein, hypertension, diabetes, cardiovascular disease (CVD) (defined as a composite outcome encompassing coronary heart disease, cerebrovascular events,

peripheral artery disease, and heart failure, as established by the Framingham criteria[17]), and use of medication (ACEIs or ARBs).

We also included a variable accounting for the number of hours the accelerometer was worn in all adjusted models where accelerometry data were used as the primary definition of PA. Additionally, to avoid collinearity with light PA and MVPA, we adjusted the models using accelerometer data for quartiles of sedentary time rather than using it as a continuous variable.

Statistical analysis

For the present study, we included all individuals with available exposure, outcome and covariate data, regardless of kidney function at baseline. For our secondary aims, we estimated the incidence rate ratios (IRR) between groups and excluded those with CKD at baseline. All analyses incorporated survey weights established for HCHS/SOL and its ancillary studies to account for the complex sampling design and ensure population representativeness. We used the statistical software R v4.4.2 (R Foundation for Statistical Computing, Vienna, Austria).

Missing values

For our primary analyses, we used a complete case approach, excluding participants with missing data on variables relevant to each analysis. To address missing income data, we substituted missing values from V1 with data from V2 where available, assuming relative income stability over the follow-up period. To account specifically for missing accelerometer data, we followed the strategy used in prior HCHS/SOL studies, applying inverse probability weighting (IPW) based on a model predicting adherence. The final weight combined the IPW weight with the HCHS/SOL sampling weight to produce population-representative estimates.[18]

Inclusion and exclusion criteria

From the 16,415 individuals in the HCHS/SOL cohort, 5,744 were missing at least one outcome of interest; in most cases this was due to non-completion of the V2 examination due to death, study dropout or other reasons. Of the remaining 10,671 participants, 2,065 were non-adherent to the accelerometer protocol. Among the 8,606 adherent participants, 37 had no GPAQ data, and of the remaining individuals, 496 were missing covariates. For the main outcomes analysis, we included a total of 8,073 participants who had complete information for the exposure, outcome, and covariates, and were adherent to the accelerometer protocol. Of these included individuals, 866 had CKD at baseline (defined as eGFR less than 60 ml/min per $1.73m^2$ or UACR equal to or more than 30 mg/g). Consequently, after excluding these, we included 7,177 individuals in the incident CKD analysis **(Figure 1).**

Descriptive analysis and modeling approach

We included a descriptive characterization of the study population, presenting baseline characteristics as frequencies and percentages stratified by MVPA levels (Accelerometer-measured, Total self-reported MVPA, and recreational MVPA), to compare different distribution of PA by type of measurement approach,

To examine the relationship between PA and kidney function, we employed two primary analytical approaches. First, we examined the association between baseline PA measurements and longitudinal kidney function outcomes (percent change in eGFR per year and change in UACR per year) using linear regression models. To mitigate potential reverse causation (reduced kidney function leading to fatigue that decreases PA), we adjusted for baseline kidney function measures.

Second, for our binary outcome (incident CKD), we implemented Poisson regression models with an offset for the time between V1 and V2. We used these models to estimate IRR across accelerometry quartiles and between self-reported PA. Additionally, we conducted sensitivity analyses excluding individuals with CKD at baseline for the continuous kidney function outcomes to further address reverse causation concerns.

To assess effect modification, we included interaction terms to test whether associations between PA and kidney function changes differed by gender, age group, diabetes status, and homemaker status. The selection of interaction terms was informed by prior research using HCHS/SOL data, which identified gender-specific differences in kidney function trajectories. These studies found that women exhibited higher levels of sedentary time than men, and that sedentary time was significantly associated with eGFR decline among women, but not among men.[8,16] Based on prior literature[9], we also tested effect modification by age group and diabetes status. Finally, we examined effect modification by homemaker status, as household-related PA was not captured by the GPAQ. For all interaction terms, we used a significance threshold of $p<0.05$ to identify meaningful effect modification, followed by presentation of stratified analyses for significant interactions.

RESULTS

The baseline characteristics of the 8,073 participants eligible for this analysis are summarized in **Table 1**. The overall mean age was 42.5 years, and 55.7% were women. Based on the PAG 2018 classification, 23.4% of participants were classified as inactive, 13.7% as insufficiently active, 11.3% as active, and 51.6% as highly active. Demographic and health characteristics varied across activity levels. Compared with the inactive group, highly active participants were younger (mean 39.9 vs. 45.9 years), more likely to be male (53.1% vs. 32.6%), more likely to be born in the U.S. (23.8% vs. 14.9%), and more likely to have full-time employment (39.8% vs. 28.0%). Additionally, the highly active group had a lower prevalence of baseline cardiometabolic conditions, including hypertension (18.1% vs. 30.4%), diabetes (12.0% vs. 20.2%), and CVD (20.3% vs. 26.8%), as well as lower BMI (29.1 vs. 30.5 kg/m^2) and inflammatory markers (CRP: 3.4 vs. 4.6 mg/L). Kidney function parameters also differed by activity level, with the highly active group showing higher eGFR (112.6 vs. 106.5 mL/min/1.73m^2) and lower UACR (20.7 vs. 29.7 mg/g) compared to inactive participants. The overall eGFR percent change per year among the participants included was -0.61% (95% CI: -0.68% to -0.54%), while the overall UACR change per year was +2.03 mg/g (95% CI: 0.98 to 3.07).

Using the subsets of the GPAQ questionnaire that ascertained type of activity, we found that only 8.4% were classified as active and 16.8% classified as highly active based on recreational MVPA, compared to 11.3% and 51.6% based on total MVPA (Table S1). We also observed differences between accelerometer-measured and self-reported MVPA levels (Table S2). By GPAQ, over half of participants were classified as highly active (>300 min/week), whereas only about 25% exceeded the lowest Q4 cutoff (219.5 min/week) using accelerometry. Differences in baseline UACR, diabetes, hypertension, and CVD were more pronounced across activity levels when MVPA was measured with accelerometry.

Accelerometer-Measured Physical Activity and Changes in Kidney Function

In fully adjusted models, neither light PA nor MVPA showed statistically significant associations with the change in eGFR per year. The point estimate for our association measure suggested that each 15-minute/day increase in light PA was associated with a 0.009% decrease in eGFR per year (95% CI: -0.024% to 0.006%). Similarly, each 15-minute/day increase in MVPA was associated with a 0.012% decrease in eGFR per year (95% CI, -0.046% to 0.023%) (Table 2).

When examining associations with UACR, the fully adjusted model showed that each 15-minute/day increase in light PA was associated with a non-significant 0.218 unit increase in UACR per year (95% CI, -0.082 to 0.517). For MVPA, there was a non-significant UACR decrease of 0.102 units per year (95% CI, -0.839 to 0.636) per 15-minute/day increase (Table 2).

Self-Reported Physical Activity and Changes in Kidney Function

Total self-reported MVPA showed no significant relationship with eGFR changes, with the point estimate suggesting that each 15-minute/day increase was associated with a 0.003% increase in eGFR per year (95% CI, -0.002% to 0.008%) in fully adjusted models (Table 3). Recreational MVPA yielded stronger positive coefficients for eGFR trajectory compared to total MVPA, though these associations did not reach statistical significance after covariate adjustment. On the other hand, recreational MVPA demonstrated statistically significant protective effects on UACR. In fully adjusted models, each 15-minute/day increase in recreational MVPA was associated with a small but statistically significant reduction in UACR per year of -0.208 units (95% CI, -0.390 to -0.026) (Table 3). When exploring the adjusted means across levels of recreational MVPA, a clear pattern was not observed, and all confidence intervals included the null value. Insufficiently active and highly active individuals showed a negative estimate for annual change, while those classified as active showed a positive estimate. **(Figure 2).**

Sensitivity Analysis

In sensitivity analyses restricted to participants without CKD at baseline (n=7177), findings remained generally consistent with those observed in the overall cohort. For accelerometer-measured PA, results were similar, but the coefficients were smaller. For self-reported physical activity, total MVPA in participants without CKD showed similar but attenuated changes in annual percent eGFR. Notably, the protective association between recreational MVPA and

UACR was attenuated and not statistically significant in this subgroup (-0.050 mg/g; 95% CI, -0.111 to 0.011 mg/g).

Incidence Rate Ratios for Incident CKD by Quartiles of Accelerometer-measured PA

Among the included subjects, the number of incident CKD cases ranged from 85 to 113 across quartiles. In the fully adjusted Model 5, neither light PA nor MVPA measured by accelerometry showed statistically significant associations with the outcome across quartiles. Using Q1 as reference, light PA quartiles demonstrated IRR values of 1.01 (95% CI: 0.64-1.58) for Q2, 0.91 (95% CI: 0.52-1.57) for Q3, and 1.13 (95% CI: 0.54-2.39) for Q4, with a non-significant p-trend of 0.8610. For MVPA quartiles, the corresponding IRR values were 1.24 (95% CI: 0.81-1.91) for Q2, 1.28 (95% CI: 0.79-2.08) for Q3, and 1.19 (95% CI: 0.71-2.01) for Q4, with a p-trend of 0.4406 (Table 4). Although not reaching statistical significance, these estimates suggest a pattern of modestly increased IRR values across higher quartiles of MVPA compared to the reference group.

IRR for incident CKD by Levels of Self-Reported PA

The number of incident CKD cases across self-reported MVPA levels ranged from 27 to 282. In the fully adjusted Model 5, using the inactive group as reference, neither total MVPA nor recreational MVPA showed statistically significant associations with incident CKD across PA levels. For total MVPA, the low, medium, and high activity groups demonstrated IRR values of 1.01 (95% CI: 0.66 to 1.53), 0.94 (95% CI: 0.58 to 1.52), and 1.15 (95% CI: 0.84 to 1.60) respectively, with a non-significant p-trend of 0.3659. For recreational MVPA, the corresponding IRR values were 0.87 (95% CI: 0.48 to 1.57), 1.45 (95% CI: 0.87 to 2.44), and 1.00 (95% CI: 0.62 to 1.60), with a p-trend of 0.6581 (Table 5). Using the self-reported PA data, we observed that considering total MVPA, highly active individuals had a positive IRR compared with the reference group. For recreational PA, the medium activity group had a non-significant but higher incidence compared with the inactive group.

Effect modification

We identified several statistically significant interaction terms at the nominal $p<0.05$ criterion, though no consistent pattern emerged across outcomes. From the 48 interaction models tested, we found 4 terms for analyses examining change in kidney function measures (linear models of eGFR and UACR) and 2 for analyses examining risk of incident CKD (Poisson models) that met the $p<0.05$ criterion.

Age significantly modified the association between total self-reported MVPA and changes in UACR per year (p for interaction = 0.00448). Stratified analyses revealed that participants aged 50 years and older experienced a small but statistically significant yearly decrease in UACR per 15-minute increment in self-reported MVPA (β = -0.232; 95% CI: -0.385 to -0.080). In contrast, among participants younger than 50, the association was positive but not statistically significant (β = 0.014; 95% CI: -0.077 to 0.105).

Gender significantly modified the association between accelerometer-measured light PA and UACR change (p for interaction = 0.00922). In stratified models, men showed a significant higher UACR per 15-minute increment in light PA (β = 0.446; 95% CI: 0.039 to 0.853), whereas women demonstrated a non-significant decrease (β = -0.139; 95% CI: -0.541 to 0.262).

Diabetes status modified associations in two models. First, a significant interaction was observed between diabetes and the association between accelerometer-measured light PA and UACR change (p for interaction = 0.0463). However, stratified analyses showed non-significant positive coefficients in both diabetic and non-diabetic groups. Second, in Poisson models of incident CKD, diabetes significantly modified the association with accelerometer-measured MVPA (p=0.0308). Among the 151 diabetic participants with incident CKD, nearly all cases (n=150) involved elevated UACR, with only 12 showing low eGFR. For participants with diabetes, each 15-minute increase in MVPA was associated with higher CKD risk (IRR: 1.12; 95% CI: 1.02–1.22), a finding that remained significant after adjusting for hypertension, CVD, and self-reported work-related MVPA. In contrast, among non-diabetics, the association was inverse but not significant (IRR: 0.95; 95% CI: 0.82–1.09).

Homemaker status also modified associations in two models. In the model examining light PA and percent change in eGFR per year (p=0.0168), homemakers and non-homemakers showed opposite directional trends, with a positive coefficient observed among homemakers and a negative coefficient among non-homemakers; however, neither association reached statistical significance. In the Poisson model (p=0.0161), a significant protective association was found among homemakers (IRR = 0.90; 95% CI: 0.81 to 1.00) per 15-minute higher increment in recreational MVPA, whereas non-homemakers exhibited a non-significant positive estimate (IRR = 1.05; 95% CI: 0.99 to 1.10).

DISCUSSION

In this study of Hispanic/Latino adults, neither accelerometer-measured PA nor total self-reported MVPA was significantly associated with percent change in eGFR per year or yearly change in UACR after adjusting for demographic, socioeconomic, lifestyle, and clinical factors. However, self-reported recreational MVPA as measured by the GPAQ questionnaire demonstrated a small but statistically significant protective effect on albuminuria, with each 15-minute/day increase associated with a UACR reduction per year of -0.208 (95% CI: -0.390 to -0.026). These findings suggest that kidney function, as measured by eGFR, may remain stable over the short-to-medium term, while albuminuria, a marker of early kidney damage, could improve with increased recreational PA time.

Nevertheless, when examining the adjusted mean change in ACR per year across recreational PA levels no specific trend was observed (Figure 2). These observed differences should be interpreted with caution, as this exploratory analysis was limited by reduced sample sizes within each activity category and lacked *a priori* hypothesis linking recreational PA specifically to albuminuria.

Notably, in sensitivity analyses restricted to participants without baseline CKD, the protective effect on UACR was attenuated and not statistically significant. This is expected, since the baseline level of UACR in a healthier group may not have been high enough to show large changes. Finally, differences in PA levels between accelerometer and self-reported measures have been observed in previous studies and could be influenced by social desirability bias leading to overreporting of self-reported PA.[19,20]

Our findings align with previous studies reporting modest or null associations between PA and eGFR decline across diverse populations with similar baseline characteristics and follow-up times. [21–23]A longitudinal study conducted in the Netherlands examined changes in eGFR over five years in relation to self-reported PA levels among individuals with a mean baseline eGFR of 107.9 mL/min/1.73 m^2. The study found that, compared to active individuals, those who were inactive experienced a greater decline in eGFR (β = -0.57 mL/min/1.73 m^2; 95% CI: -1.70 to 0.56), which corresponds to approximately -0.11 units per year. Similarly, both moderately inactive (β = -0.26; 95% CI: -0.84 to 0.31) and moderately active individuals (β = -0.22; 95% CI: -0.66 to 0.22) showed greater declines in eGFR compared to the reference group, although these associations were not statistically significant.[23] An Australian study found a non-significant association between self-reported leisure time activity levels and incident low eGFR after 5 years (OR 1.17, 95% CI: 0.91 to 1.50) when comparing inactive vs. active individuals (defined as ≥150min/week).[22] Several methodological differences distinguish our study from these investigations. Both previous studies examined predominantly European white populations, with the Australian cohort having a mean age of approximately 59 years. Additionally, different eGFR calculation methods were employed—the Dutch cohort used a cystatin-based formula, while the Australian cohort used the Modification of Diet in Renal Disease Study Equation.[22,23]

In addition, study duration may play an important role in detecting associations. A study including only white and black participants with a median follow-up of 24 years, using questionnaires focused on recreational PA, found a significant protective effect against incident CKD (based on eGFR decline only), with a hazard ratio of 0.89 (95% CI: 0.81 to 0.97) when comparing highly active to inactive groups.[24]

The observed protective association between self-reported recreational MVPA and decreased UACR is consistent with literature highlighting the benefits of recreational PA for kidney health, particularly among population groups with higher levels of albuminuria, such as diabetic populations.[5,25] A study using NHANES data from 2007-2018 described that recreational MVPA as measured by GPAQ was associated with lower UACR levels, although it did not assess longitudinal outcomes.[25] Another study using the same year range, which included populations with prediabetes and diabetes, reported reduced odds of high UACR among individuals with controlled diabetes or prediabetes at recreational PA levels ≥300 min/week (OR: 0.69, 95% CI: 0.49 to 0.95), a result that was not significant at the same intensity of occupational and transportation-related PA. Considering only Mexican Americans, the association between the odds of albuminuria and meeting the PAG guidelines with recreational PA was not significant (OR: 0.85, 95% CI: 0.56 to 1.30).[26]

Collectively, these findings suggest that engaging in any form of PA may help preserve kidney function. This aligns with Hannan *et al.*, who found that reducing sedentary time was beneficial for kidney disease risk among Hispanic/Latino individuals[8]. However, when considering MVPA specifically, both our study and Ricardo *et al*. suggest that any protective effect on the kidneys is unclear and may vary across different population subgroups and types of activity. For instance, Ricardo reported mixed results when comparing ideal versus inactive PA levels for incident CKD, and we similarly found inconsistent associations across different activity levels.[16] These similarities are notable despite methodological differences between studies, suggesting that the association between MVPA and kidney function among Hispanic/Latino populations may be complex.

One hypothesis that warrants further investigation is that this population may report different PA domains in distinct ways, which could influence the observed associations. Recreational MVPA is likely reported differently than occupational or transportation MVPA, as recreational activities tend to be better recalled and may be subject to more social desirability bias[19,20,27].

Effect Modification

Homemaker status and diabetes emerged as effect modifiers, each showing significant interactions in more than one model. Homemakers represent a considerable percentage of our study population, almost 50%. Previous HCHS/SOL studies have described lower cardiovascular health scores in both males and females who are older than 45 and are homemakers, with women homemakers showing lower levels of PA.[28] Our study added data on kidney outcomes. Among homemakers, recreational MVPA was associated with a lower incidence of CKD when defined as a binary outcome, a pattern not observed among non-homemakers. While occupation is a key determinant of PA patterns, we currently lack a clear explanation for why homemakers might derive a potentially greater benefit from recreational PA, and no literature was found related to this specific outcome. Our findings of a significant interaction could be related to differences in biological mechanisms or in reporting, given that recreational PA could be reported differently among homemakers and non-homemakers. This finding is especially interesting within this occupational group and warrants further investigation. Ideally, future PA questionnaires should explicitly capture household-related PA.

Diabetes status also modified associations in two models. Given that diabetes is a major risk factor for CKD, it is plausible that it influences how PA affects kidney outcomes. Our incident CKD events among Hispanic/Latino individuals with diabetes were primarily due to increased albuminuria, which has also been noted in previous studies with short follow-up.[29] The stratified analysis suggested a higher incidence of CKD in diabetic individuals with an increase of 15 min/day in accelerometer-measured MVPA (IRR: 1.12, 95% CI: 1.02 to 1.23). After performing exploratory analyses, we found an increasing trend in CKD incidence across higher MVPA quartiles among participants with diabetes. These findings persisted even after adjusting for comorbidities (hypertension, CVD). Given previous evidence of increased CKD among individuals with higher working hours[30], we further adjusted for self-reported work-related MVPA, but the result remained significant. While these findings should be interpreted cautiously, they highlight the need for further research into how diabetes may alter the impact of PA on kidney health.

We also observed interaction effects by gender and age. Men exhibited a significant increase in UACR with greater light-intensity PA, whereas women did not. Additionally, adults aged 50 years and older showed a small but significant reduction in UACR with increasing total self-reported MVPA, consistent with prior HCHS/SOL findings suggesting stronger PA benefits in older populations.[9] While not all interaction terms reached statistical significance, these patterns suggest that demographic and clinical characteristics may influence the relationship between PA and kidney outcomes. However, given the number of interaction tests performed, the possibility of chance findings due to multiple comparisons cannot be ruled out.

Strengths and Limitations

Some limitations should be noted in our study. PA and covariates were measured only at baseline, preventing assessment of changes over time. The relatively short follow-up (~6 years) may not fully capture long-term kidney function decline, especially in a relatively young and healthy cohort. Small numbers of incident CKD cases across PA categories limited our ability to detect statistically significant associations. Additionally, we did not capture detailed information on PA intensity, duration, or context beyond broad categories. Finally, the variability in PA and kidney function measurement methods in the published literature, along with limited evidence in Hispanic/Latino adults, restricts comparison with other studies.

Despite these limitations, our study has notable strengths, including the use of both measured and self-reported PA data in a well-characterized, population-based cohort of Hispanic/Latino adults. Our models accounted for a wide range of confounders, enhancing internal validity. In addition, this study contributes new insights by comparing accelerometer-based and self-reported PA measures within a diverse Hispanic/Latino cohort. The observed differences, particularly the stronger associations for self-reported recreational MVPA, underscore the importance of considering PA type and measurement method. Recreational activities may offer unique physiological benefits compared to occupational or transportation-related PA, potentially explaining their associations with positive kidney outcomes

Future Research

The recently completed third visit (V3) of the HCHS/SOL cohort and ongoing studies such as PASOS will enable longer-term follow-up and provide a richer basis for examining longitudinal changes in kidney function. Future research should investigate the biological mechanisms underlying the observed benefits of recreational PA on albuminuria on Hispanic/Latino subgroups, such as homemakers and diabetics.

Conclusion

In conclusion, while no significant associations were observed between overall PA levels and eGFR decline, our findings suggest that recreational MVPA may be associated with less reduced albuminuria in Hispanic/Latino adults in the U.S. These findings emphasize the importance of distinguishing between PA types when assessing kidney outcomes. Future research combining objective and self-reported PA measures, with longer follow-up, is needed to confirm these associations and explore targeted strategies to preserve kidney function among this population.

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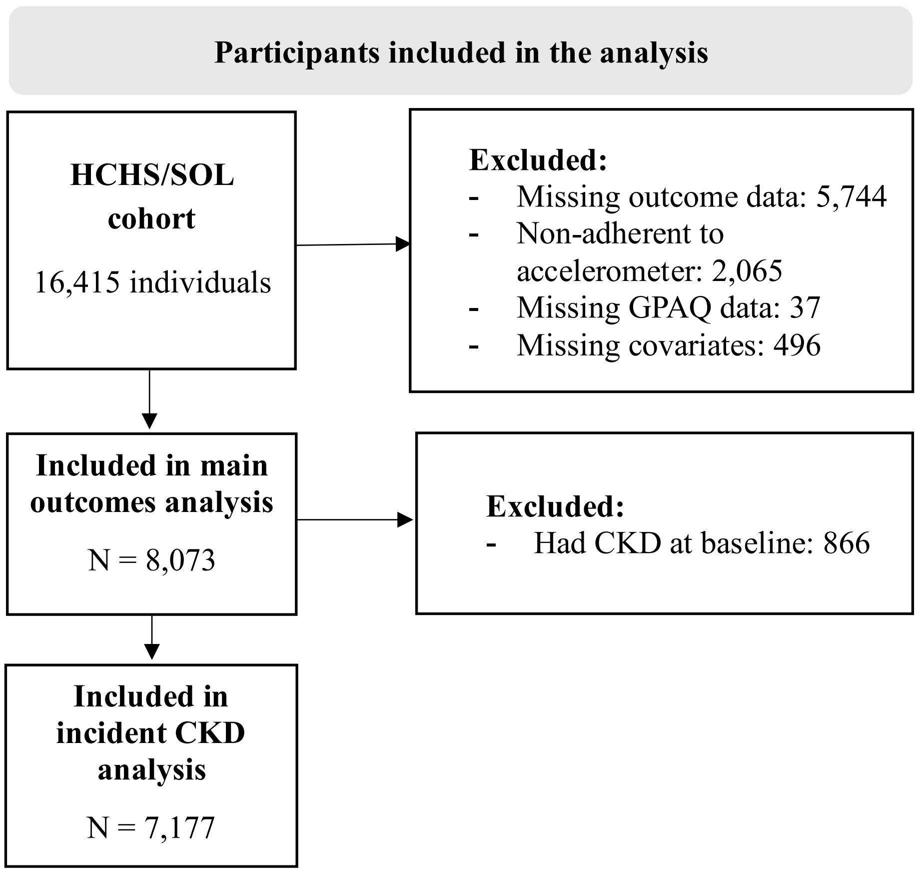
APPENDIX

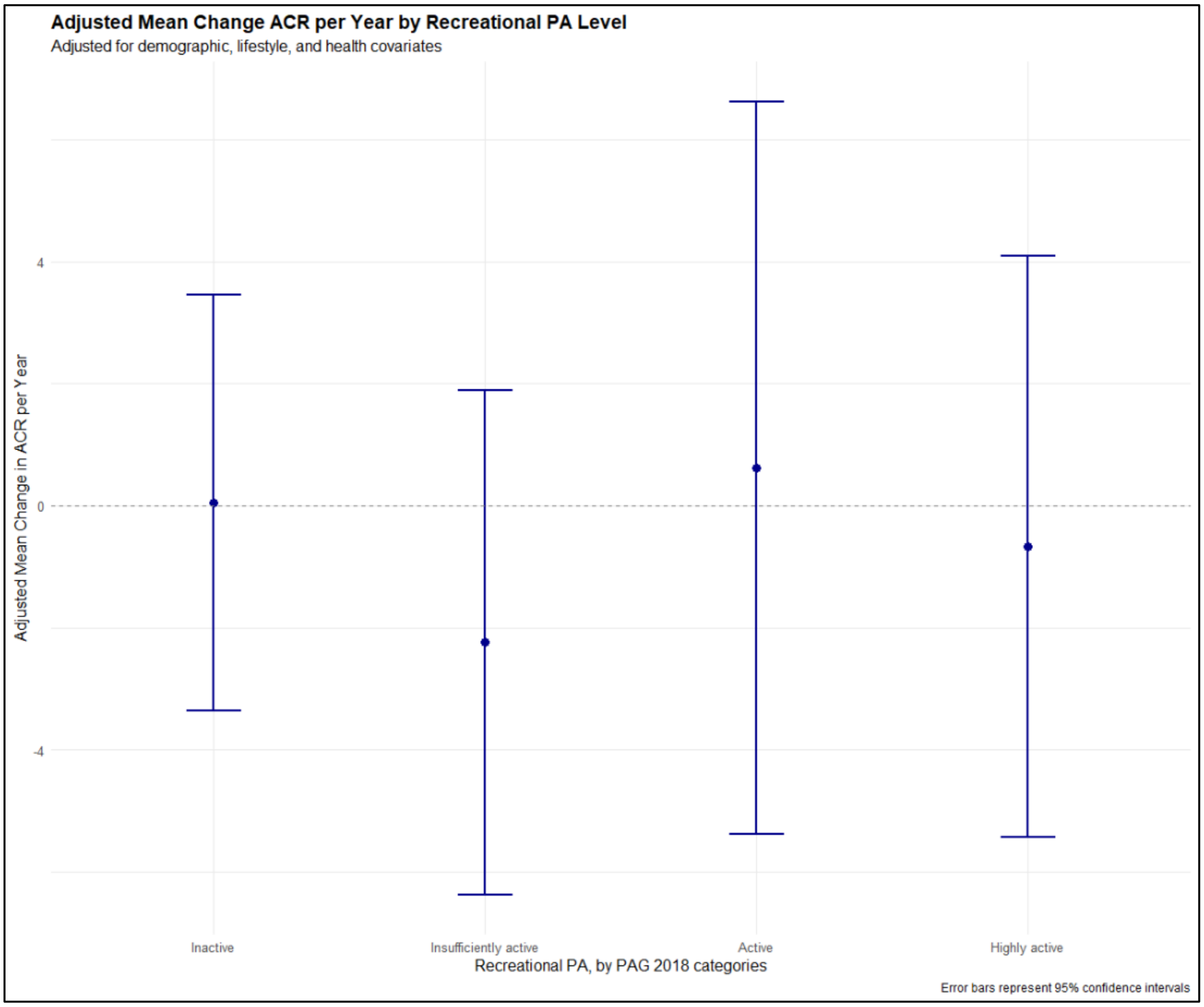
TABLES AND FIGURES

Figure 1. Participants included in the analysis



Missing data summary: UACR (V2): 30.7%, eGFR (V2): 29.8%, and accelerometer-derived measures (sedentary time, light PA, and MVPA): 22.3%, had the highest rates of missing data. ACR V1 had 5.3% missing values. Demographic, socioeconomic, and clinical variables (including income, medication use, employment status, eGFR V1, and CRP) had <5% missing data. All other variables (including lifestyle factors, anthropometrics, and chronic conditions) had <1% missing data.

Figure 2. Predicted change in UACR per year by category of self-reported recreational PA.



The predicted values were based on the fully adjusted model including baseline age, gender, study center, country of birth, Hispanic/Latino background, language preference, education, and annual household income, employment status, including whether the participant was a homemaker, current occupation, smoking status, alcohol use level, Alternative Healthy Eating Index–2010 (AHEI-2010) score, sedentary time (defined as less than 10 counts per minute, measured by accelerometry), and hours of accelerometer wear time, bodymass index (BMI), waist-to-hip ratio, baseline estimated glomerular filtration rate (eGFR), baseline urine albumin-to-creatinine ratio (UACR), baseline C-reactive protein (CRP), comorbid conditions (including hypertension, diabetes, and cardiovascular disease), and the use of angiotensin-converting enzyme inhibitors (ACEIs) and angiotensin receptor blockers (ARBs).

Table 1. Baseline Characteristics by Self-Reported Total MVPA Levels According to PAG 2018.

	Total	Inactive	Insufficiently active	Active	Highly active
Variable	**N=8,073**	**N=1890**	**N=1106**	**N=909**	**N=4168**
Age (yrs), mean (95% CI)	42.5 (41.8, 43.1)	45.9 (44.9, 47)	46.3 (44.8, 47.7)	44.3 (42.7, 45.9)	39.9 (39.1, 40.7)
Women, % (95% CI)	55.7 (54.0, 57.4)	67.4 (64.6, 70.3)	67.2 (62.7, 71.7)	64.1 (59.3, 68.9)	46.9 (44.3, 49.4)
Center, % (95 %CI)					
Bronx	25.7 (22.7, 28.6)	20.3 (16.8, 23.7)	30.2 (24.4, 36.1)	25.8 (20.6, 31.1)	26.6 (23.2, 30)
Chicago	17.6 (15.3, 19.9)	14.6 (11.9, 17.4)	17.9 (14.2, 21.6)	18.2 (14.4, 22.1)	18.5 (16, 21)
Miami	29.6 (25.3, 34.0)	40.9 (34.6, 47.1)	29.5 (23.6, 35.4)	29.5 (23.9, 35.1)	25.4 (21.2, 29.5)
San Diego	27.1 (23.4, 30.9)	24.2 (19.7, 28.8)	22.4 (17.1, 27.6)	26.4 (20.4, 32.4)	29.5 (25.4, 33.6)
Born in the US, % (95% CI)	20.0 (18.2, 21.9)	14.9 (11.8, 17.9)	14.1 (10.9, 17.4)	17.9 (13.9, 21.9)	23.8 (21.3, 26.2)
Hispanic/Latino Background, % (95% CI)					
Dominican	9.3 (7.6, 11.0)	7.8 (6, 9.6)	11.5 (8.3, 14.7)	9.7 (6.4, 13.1)	9.3 (6.7, 11.8)
Central American	7.3 (6.1, 8.5)	6.1 (4.7, 7.4)	8.2 (6.1, 10.2)	8.3 (5.8, 10.8)	7.4 (6, 8.8)
Cuban	21.0 (17.5, 24.6)	31.9 (26, 37.7)	21.4 (16.3, 26.4)	20.1 (15.3, 25)	16.9 (13.8, 20.1)
Mexican	39.7 (36.1, 43.3)	33.3 (28.7, 37.9)	36 (30.5, 41.6)	40.8 (34.8, 46.8)	42.8 (38.9, 46.8)
Puerto Rican	14.7 (12.9, 16.5)	14 (11.4, 16.6)	16.8 (12.3, 21.3)	12.6 (9.6, 15.7)	14.9 (12.8, 17)
South American	4.9 (4.1, 5.6)	4.6 (3.5, 5.6)	3.6 (2.4, 4.8)	6.5 (4, 9.1)	5 (4.1, 5.9)
More than one/Other	3.1 (2.5, 3.8)	2.4 (1.3, 3.5)	2.6 (0.9, 4.2)	1.9 (0.6, 3.3)	3.8 (2.8, 4.8)
Language: Spanish, % (95% CI)	77.7 (75.7, 79.8)	81.8 (78.6, 85.1)	79.6 (74.4, 84.7)	82.1 (78.2, 85.9)	74.9 (72.3, 77.5)
Education, % (95% CI)					
Less than high school	31.4 (29.5, 33.3)	34.7 (31.6, 37.9)	34.3 (29.5, 39.1)	35.5 (30.7, 40.3)	28.7 (26.4, 31)

High school/GED	27.4 (25.6, 29.1)	27 (23.8, 30.3)	23.7 (19.8, 27.6)	23.3 (19.2, 27.5)	29.2 (26.6, 31.7)
Greater than high school/GED	41.2 (39.1, 43.3)	38.2 (35, 41.5)	42 (36.7, 47.3)	41.2 (36.2, 46.2)	42.1 (39.3, 45)
Homemaker, % (95% CI)	44.7 (43.0, 46.4)	52.6 (49.2, 55.9)	54.6 (49.8, 59.4)	53.6 (48.8, 58.4)	37.6 (35.1, 40.1)
Employment status, % (95% CI)					
Retired and not employed	8.8 (7.8, 9.8)	11 (9.1, 13)	14.1 (10.6, 17.5)	11.5 (8.7, 14.2)	6.2 (5.1, 7.2)
Not retired and not employed	40.0 (38.1, 41.8)	47.5 (44.3, 50.7)	46.4 (41.2, 51.6)	48.2 (42.8, 53.5)	34 (31.4, 36.6)
Part-time	17.4 (16.1, 18.6)	13.4 (11.2, 15.7)	13.3 (10.1, 16.6)	16 (12.4, 19.6)	20.1 (18.2, 21.9)
Full-time	33.9 (32.3, 35.4)	28 (25.2, 30.9)	26.2 (22, 30.5)	24.4 (20.4, 28.4)	39.8 (37.5, 42)
Current Employment, % (95% CI)					
Not employed	48.7 (46.8, 50.6)	58.6 (55.3, 61.8)	60.4 (55.6, 65.2)	59.5 (54.4, 64.6)	40.1 (37.5, 42.8)
Non-skilled worker	13.8 (12.6, 15.1)	10.8 (8.7, 13)	10.5 (7.5, 13.5)	10.1 (7.2, 12.9)	16.5 (14.7, 18.3)
Service worker	10.2 (9.0, 11.4)	8.7 (6.8, 10.6)	5.9 (4.3, 7.5)	7 (4.6, 9.4)	12.4 (10.6, 14.2)
Skilled worker	11.6 (10.5, 12.7)	9 (6.9, 11)	9.9 (6.4, 13.3)	9.6 (7, 12.2)	13.5 (11.8, 15.1)
Professional/administrative	6.6 (5.6, 7.6)	5.1 (3.7, 6.6)	6.6 (4.3, 8.9)	9.9 (6.8, 13)	6.5 (5.2, 7.7)
Other occupation	9.0 (7.8, 10.2)	7.8 (5.9, 9.6)	6.7 (3.9, 9.5)	3.9 (2.4, 5.5)	11 (9.2, 12.8)
Income category, % (95% CI)					
Less than $10,000	14.5 (13.2, 15.8)	17.8 (15.2, 20.5)	21.1 (16.3, 25.9)	13.4 (10.3, 16.5)	11.9 (10.5, 13.3)
$10,001-$20,000	32.1 (30.2, 34.0)	35.1 (32.1, 38)	31.4 (26.7, 36.1)	35.6 (30.7, 40.5)	30.5 (28, 32.9)
$20,001-$40,000	33.5 (31.6, 35.3)	29.7 (26.6, 32.8)	31.5 (26.9, 36)	29.5 (24.7, 34.3)	36.1 (33.4, 38.9)
$40,001-$75,000	14.5 (13.0, 15.9)	12.1 (9.9, 14.3)	11.4 (7.7, 15.2)	16.9 (13.1, 20.6)	15.6 (13.7, 17.5)
More than $75,000	5.5 (4.3, 6.6)	5.3 (3.7, 6.9)	4.6 (2, 7.2)	4.6 (2.8, 6.5)	5.9 (4.4, 7.4)

AHEI Score, mean (95% CI)	47.9 (47.6, 48.3)	47.1 (46.5, 47.7)	48.2 (47.6, 48.9)	48.6 (47.9, 49.3)	48.1 (47.6, 48.5)
Sedentary time (min/day), mean (95% CI)	480.7 (473.2, 488.1)	483.4 (471.9, 494.9)	495.8 (479.7, 511.8)	499.6 (483.8, 515.4)	472.4 (463.1, 481.7)
Accel. wear time (hrs), mean (95% CI)	15.9 (15.7, 16.0)	15.4 (15.2, 15.6)	15.8 (15.5, 16)	15.9 (15.6, 16.2)	16.0 (15.9, 16.2)
Cigarette use, % (95% CI)					
Never	63.3 (61.6, 65.1)	60.9 (57.8, 64)	66.1 (61.2, 71)	66.6 (61.8, 71.3)	63 (60.5, 65.5)
Former	17.9 (16.7, 19.1)	20.6 (18, 23.1)	17.9 (13.8, 21.9)	17 (13.6, 20.5)	17 (15.5, 18.6)
Current	18.8 (17.1, 20.4)	18.5 (15.9, 21.1)	16 (12.3, 19.7)	16.4 (12.3, 20.5)	20 (17.6, 22.4)
Alcohol use level, % (95% CI)					
No use	50.2 (48.1, 52.3)	57.5 (54.1, 60.9)	57.4 (52.3, 62.6)	53.5 (48.5, 58.4)	45.1 (42.4, 47.8)
Low risk	44.6 (42.5, 46.6)	37.8 (34.6, 41.1)	38.4 (33.5, 43.4)	42.6 (37.6, 47.6)	49 (46.3, 51.6)
High risk	5.2 (4.4, 6.1)	4.7 (3.0, 6.4)	4.1 (2.3, 5.9)	4 (2.3, 5.6)	6 (4.7, 7.2)
BMI, mean (95% CI)	29.5 (29.3, 29.7)	30.5 (30.1, 30.9)	29.8 (29.2, 30.4)	29.6 (29, 30.2)	29.1 (28.8, 29.3)
Waist-to-hip ratio, mean (95% CI)	0.9 (0.9, 0.9)	0.9 (0.9, 0.9)	0.9 (0.9, 0.9)	0.9 (0.9, 0.9)	0.9 (0.9, 0.9)
eGFR (ml/min per 1.73m^2, mean (95% CI)	110.0 (109.3, 110.8)	106.5 (105.4, 107.7)	106.0 (104.0, 107.9)	108.6 (106.8, 110.5)	112.6 (111.7, 113.5)
UACR (mg/g), mean (95% CI)	24.6 (21.3, 27.8)	29.7 (22.4, 37)	26.9 (18.3, 35.6)	31.2 (17.8, 44.7)	20.7 (16.7, 24.8)
CRP (mg/L), mean (95% CI)	3.9 (3.6, 4.2)	4.6 (4.3, 5)	5 (3.4, 6.6)	3.7 (3.4, 4.1)	3.4 (3.1, 3.6)
Hypertension (Yes), % (95% CI)	22.6 (21.1, 24.1)	30.4 (27.5, 33.3)	27.5 (23.6, 31.3)	24 (20.4, 27.5)	18.1 (16.5, 19.8)
Diabetes (Yes), % (95% CI)	15.6 (14.5, 16.8)	20.2 (17.9, 22.5)	21.3 (17.6, 25.1)	18.1 (14.8, 21.5)	12 (10.7, 13.3)
CVD (Yes), % (95% CI)	23.3 (21.8, 24.7)	26.8 (23.8, 29.8)	28.5 (24.5, 32.4)	25.2 (21.3, 29.1)	20.3 (18.3, 22.3)
ACEI use, % (95% CI)	8.7 (7.9, 9.6)	11.2 (9.4, 12.9)	12.9 (10.1, 15.6)	9.7 (7.6, 11.8)	6.6 (5.7, 7.5)
ARB use, % (95% CI)	3.6 (3.1, 4.1)	4.6 (3.5, 5.7)	4.1 (2.7, 5.6)	4.3 (2.8, 5.8)	2.9 (2.3, 3.6)

Table 2. Change in eGFR and UACR per year, per 15min/day increase in accelerometer-measured PA

	eGFR	UACR
	Annual percent change, (95% CI)	**Annual change (95% CI)**
Light PA		
Model 1	0.006 (-0.002, 0.015)	0.084 (-0.078, 0.245)
Model 2	0.007 (-0.002, 0.016)	0.077 (-0.090, 0.243)
Model 3	0.003 (-0.006, 0.013)	0.094 (-0.099, 0.286)
Model 4	-0.007 (-0.022, 0.008)	0.163 (-0.115, 0.440)
Model 5	-0.009 (-0.024, 0.006)	0.218 (-0.082, 0.517)
MVPA		
Model 1	0.029 (-0.005, 0.064)	0.061 (-0.541, 0.662)
Model 2	0.000 (-0.033, 0.034)	-0.055 (-0.702, 0.592)
Model 3	-0.002 (-0.036, 0.031)	-0.051 (-0.709, 0.607)
Model 4	-0.012 (-0.046, 0.023)	-0.102 (-0.839, 0.636)
Model 5	-0.010 (-0.044, 0.025)	0.048 (-0.637, 0.732)

Model 1 is an unadjusted model. Model 2 included baseline age, gender, study center, country of birth, Hispanic/Latino background, language preference, education, and annual household income). Model 3 included variables in Model 2 and employment status, if homemaker, and current occupation. Model 4 included all variables in Model 3 and smoking status, alcohol use level, Alternative Healthy Eating Index–2010 score, sedentary time (less than 10 counts/min, measured by accelerometry), hours wearing the accelerometer. Model 5 included all variables in Model 4 and BMI, waist-to-hip ratio, baseline eGFR (except for % change in eGFR), baseline urine ACR, baseline CRP, comorbidities (hypertension, diabetes, CVD), and use of ACEIs, and use of ARBs.

Table 3. Change in eGFR and UACR per year, per 15min/day increase in self-reported PA (N=8073)

	eGFR	UACR
	Percent change per year (95% CI)	**Change per year (95% CI)**
Total MVPA		
Model 1	0.010 (0.005, 0.015)	-0.027 (-0.099, 0.045)
Model 2	0.005 (-0.000, 0.010)	-0.037 (-0.113, 0.039)
Model 3	0.003 (-0.002, 0.009)	-0.035 (-0.109, 0.039)
Model 4	0.003 (-0.002, 0.008)	-0.045 (-0.123, 0.033)
Model 5	0.003 (-0.002, 0.008)	-0.047 (-0.131, 0.037)
Recreational MVPA		
Model 1	0.041 (0.022, 0.060)	-0.165 (-0.307, 0.024)
Model 2	0.014 (-0.005, 0.033)	-0.125 (-0.282, 0.032)
Model 3	0.017 (-0.002, 0.036)	-0.134 (-0.295, 0.028)
Model 4	0.016 (-0.002, 0.035)	-0.135 (-0.308, 0.038)
Model 5	0.017 (-0.002, 0.036)	**-0.208 (-0.390, -0.026)**

Model 1 is an unadjusted model. Model 2 included baseline age, gender, study center, country of birth, Hispanic/Latino background, language preference, education, and annual household income). Model 3 included variables in Model 2 and employment status, if homemaker, and current occupation. Model 4 included all variables in Model 3 and smoking status, alcohol use level, Alternative Healthy Eating Index–2010 score, sedentary time (less than 10 counts/min, measured by accelerometry), hours wearing the accelerometer. Model 5 included all variables in Model 4 and BMI, waist-to-hip ratio, baseline eGFR (except for % change in eGFR), baseline urine ACR, baseline CRP, comorbidities (hypertension, diabetes, CVD), and use of ACEIs, and use of ARBs.

Table 4. Incidence Rate Ratios for Incident CKD by Quartiles of Light and MVPA as Measured by Accelerometry

	QUARTILES				
	Q1	Q2	Q3	Q4	*p-trend*
Light PA					
Cases/Participants*	109/1661	102/1827	91/1827	90/1862	
Model 1, IRR (95% CI)	Reference	0.82 (0.56, 1.20)	**0.66 (0.45, 0.97)**	0.78 (0.49, 1.24)	0.1840
Model 2, IRR (95% CI)	Reference	0.79 (0.54, 1.15)	**0.63 (0.43, 0.93)**	0.73 (0.41, 1.29)	0.2108
Model 3, IRR (95% CI)	Reference	0.81 (0.55, 1.18)	**0.64 (0.42, 0.96)**	0.75 (0.40, 1.40)	0.3235
Model 4, IRR (95% CI)	Reference	0.97 (0.61, 1.53)	0.87 (0.47, 1.61)	1.25 (0.49, 3.16)	0.7200
Model 5, IRR (95% CI)	Reference	1.01 (0.64, 1.58)	0.91 (0.52, 1.57)	1.13 (0.54, 2.39)	0.8610
MVPA					
Cases/Participants	101/1772	113/1839	93/1835	85/1731	
Model 1, IRR (95% CI)	Reference	0.91 (0.59, 1.41)	0.86 (0.55, 1.33)	0.64 (0.42, 0.96)	**0.0366**
Model 2, IRR (95% CI)	Reference	1.04 (0.66, 1.63)	0.98 (0.60, 1.60)	0.74 (0.46, 1.19)	0.3284
Model 3, IRR (95% CI)	Reference	1.04 (0.66, 1.63)	0.98 (0.61, 1.60)	0.73 (0.46, 1.18)	0.3559
Model 4, IRR (95% CI)	Reference	1.09 (0.67, 1.78)	1.07 (0.61, 1.87)	0.84 (0.46, 1.53)	0.7351
Model 5, IRR (95% CI)	Reference	1.24 (0.81, 1.91)	1.28 (0.79, 2.08)	1.19 (0.71, 2.01)	0.4406

Model 1 is an unadjusted model. Model 2 included baseline age, gender, study center, country of birth, Hispanic/Latino background, language preference, education, and annual household income). Model 3 included variables in Model 2 and employment status, if homemaker, and current occupation. Model 4 included all variables in Model 3 and smoking status, alcohol use level, Alternative Healthy Eating Index–2010 score, sedentary time (less than 10 counts/min, measured by accelerometry), hours wearing the accelerometer. Model 5 included all variables in Model 4 and BMI, waist-to-hip ratio, baseline eGFR, baseline urine ACR, baseline CRP, comorbidities (hypertension, diabetes, CVD), and use of ACEIs, and use of ARBs.

Table 5. IRR for Incident CKD by Levels of Self-Reported Total and Recreational MVPA

	PA LEVEL (GPAQ)				
	Inactive	Insufficiently Active	Active	Highly Active	*p-trend*
Total MVPA					
Cases/Participants	99/1652	65/966	42/788	186/3771	
Model 1, IRR (95% CI)	Reference	1.05 (0.67, 1.66)	0.83 (0.47, 1.49)	0.83 (0.60, 1.14)	<0.001
Model 2, IRR (95% CI)	Reference	1.03 (0.66, 1.63)	0.87 (0.49, 1.54)	0.97 (0.71, 1.32)	0.7780
Model 3, IRR (95% CI)	Reference	1.03 (0.65, 1.61)	0.87 (0.49, 1.53)	0.98 (0.72, 1.33)	0.8108
Model 4, IRR (95% CI)	Reference	1.03 (0.66, 1.62)	0.88 (0.50, 1.56)	1.01 (0.74, 1.37)	0.9712
Model 5, IRR (95% CI)	Reference	1.01 (0.66, 1.53)	0.94 (0.58, 1.52)	1.15 (0.84, 1.60)	0.3659
Recreational MVPA					
Cases/Participants	282/4741	27/569	31/607	52/1260	
Model 1, IRR (95% CI)	Reference	0.64 (0.39, 1.21)	1.36 (0.73, 2.52)	0.75 (0.48, 1.16)	0.3480
Model 2, IRR (95% CI)	Reference	0.77 (0.42, 1.39)	1.45 (0.81, 2.58)	0.93 (0.59, 1.47)	0.8840
Model 3, IRR (95% CI)	Reference	0.78 (0.43, 1.40)	1.46 (0.82, 2.58)	0.92 (0.58, 1.45)	0.9368
Model 4, IRR (95% CI)	Reference	0.78 (0.44, 1.40)	1.46 (0.83, 2.60)	0.93 (0.59, 1.46)	0.8849
Model 5, IRR (95% CI)	Reference	0.87 (0.48, 1.57)	1.45 (0.87, 2.44)	1.00 (0.62, 1.60)	0.6581

Model 1 is an unadjusted model. Model 2 included baseline age, gender, study center, country of birth, Hispanic/Latino background, language preference, education, and annual household income). Model 3 included variables in Model 2 and employment status, if homemaker, and current occupation. Model 4 included all variables in Model 3 and smoking status, alcohol use level, Alternative Healthy Eating Index–2010 score, sedentary time (less than 10 counts/min, measured by accelerometry), hours wearing the accelerometer. Model 5 included all variables in Model 4 and BMI, waist-to-hip ratio, baseline eGFR, baseline urine ACR, baseline CRP, comorbidities (hypertension, diabetes, CVD), and use of ACEIs, and use of ARBs.

SUPPLEMENTAL MATERIAL

S1. Table 1. Baseline Characteristics, by Self-Reported Recreational MVPA Levels According to PAG 2018

	Total	Inactive	Insufficiently active	Active	Highly active
Variable	**N=8,073**	**N=5412**	**N=626**	**N=676**	**N=1359**
Age (yrs), mean (95% CI)	42.5 (41.8, 43.1)	44.9 (44.2, 45.6)	41.1 (39.6, 42.6)	44.3 (42.2, 46.3)	36 (34.8, 37.2)
Women, % (95% CI)	55.7 (54.0, 57.4)	62.7 (60.8, 64.7)	46.9 (41.4, 52.5)	59.5 (53.5, 65.4)	39 (35.1, 43)
Center, % (95 %CI)					
Bronx	25.7 (22.7, 28.6)	28.4 (24.9, 32)	18.1 (13.2, 22.9)	18.8 (13.9, 23.7)	23.3 (19, 27.7)
Chicago	17.6 (15.3, 19.9)	16.9 (14.5, 19.3)	20.2 (15.6, 24.8)	21 (16, 25.9)	17.4 (14.5, 20.4)
Miami	29.6 (25.3, 34.0)	32.9 (27.8, 38)	25.9 (20, 31.8)	27.3 (21, 33.6)	23.1 (18.5, 27.7)
San Diego	27.1 (23.4, 30.9)	21.8 (18.4, 25.2)	35.8 (28.8, 42.8)	32.9 (26.2, 39.6)	36.1 (30.7, 41.6)
Born in the US, % (95% CI)	20.0(18.2, 21.9)	15.4 (13.4, 17.3)	20.3 (15.7, 24.8)	21 (15.2, 26.7)	31.8 (27.8, 35.8)
Hispanic/Latino Background, % (95% CI)					
Dominican	9.3 (7.6, 11.0)	11.1 (8.8, 13.5)	7.7 (4.4, 11.1)	6 (3.5, 8.5)	6.1 (4, 8.1)
Central American	7.3 (6.1, 8.5)	8 (6.6, 9.4)	6.3 (4, 8.6)	5.1 (3.2, 7)	6.6 (4.9, 8.4)
Cuban	21.0 (17.5, 24.6)	23.4 (19.1, 27.8)	15.8 (10.9, 20.8)	22.2 (16, 28.3)	16.1 (12.4, 19.7)
Mexican	39.7 (36.1, 43.3)	35.5 (31.8, 39.3)	50.8 (44, 57.6)	45.6 (39, 52.2)	44.8 (39.8, 49.8)
Puerto Rican	14.7 (12.9, 16.5)	15 (13, 17)	8.7 (5.7, 11.7)	13.5 (8.8, 18.2)	16.5 (13.3, 19.7)
South American	4.9 (4.1, 5.6)	4.3 (3.6, 5.1)	7.6 (4.3, 10.8)	5.2 (2.9, 7.5)	5.2 (3.8, 6.6)
More than one/Other	3.1 (2.5, 3.8)	2.6 (2, 3.3)	3.1 (1.3, 5)	2.4 (0.8, 3.9)	4.7 (2.7, 6.7)
Preferred language: Spanish, % (95% CI)	77.7 (75.7, 79.8)	82.3 (80, 84.5)	78.9 (74.3, 83.5)	76.4 (70.4, 82.5)	65.9 (61.6, 70.2)

Education, % (95% CI)					
Less than high school	31.4 (29.5, 33.3)	36.9 (34.5, 39.4)	25.2 (20.2, 30.2)	27.5 (22.3, 32.8)	20.4 (17.6, 23.2)
High school/GED	27.4 (25.6, 29.1)	27.5 (25.2, 29.8)	21.6 (16.8, 26.4)	27.1 (21.3, 32.9)	29.2 (25.4, 32.9)
Greater than high school/GED	41.2 (39.1, 43.3)	35.5 (33.2, 37.9)	53.2 (47.3, 59)	45.4 (38.8, 51.9)	50.4 (46.1, 54.7)
Homemaker, % (95% CI)	44.7 (43.0, 46.4)	51(48.7, 53.3)	40.8 (35.6, 46)	46.1 (40, 52.3)	29.1 (25.5, 32.7)
Employment status, % (95% CI)					
Retired and not employed	8.8 (7.8, 9.8)	10.2 (8.9, 11.4)	6.3 (3.8, 8.7)	10.9 (7.1, 14.6)	5.3 (3.7, 6.8)
Not retired and not employed	40.0 (38.1, 41.8)	41.8 (39.6, 44)	33.2 (27.6, 38.7)	36.5 (30.3, 42.7)	38.8 (34.9, 42.7)
Part-time	17.4 (16.1, 18.6)	16.4 (15, 17.8)	19.8 (15.4, 24.2)	18.6 (13.2, 23.9)	18.7 (15.8, 21.5)
Full-time	33.9 (32.3, 35.4)	31.6 (29.6, 33.6)	40.7 (35, 46.5)	34.1 (28.7, 39.5)	37.3 (33.6, 41)
Current Employment, % (95% CI)					
Not employed	48.7 (46.8, 50.6)	52 (49.9, 54.1)	39.3 (33.7, 44.9)	47.3 (40.9, 53.7)	44 (40.2, 47.9)
Non-skilled worker	13.8 (12.6, 15.1)	13.9 (12.3, 15.4)	13.7 (9.5, 17.8)	14.3 (10.3, 18.2)	13.7 (11, 16.5)
Service worker	10.2 (9.0, 11.4)	10.5 (9.1, 11.9)	13.1 (9.5, 16.8)	8.9 (6, 11.8)	8.8 (6.5, 11.2)
Skilled worker	11.6 (10.5, 12.7)	10.2 (9, 11.5)	14.3 (10.4, 18.2)	12.3 (7.7, 16.9)	14.1 (11.2, 16.9)
Professional/administrative	6.6 (5.6, 7.6)	4.6 (3.8, 5.4)	11.7 (7.9, 15.5)	8.8 (5.4, 12.2)	9.1 (6.9, 11.4)
Other occupation	9.0 (7.8, 10.2)	8.8 (7.5, 10.1)	7.8 (4.7, 10.9)	8.4 (4.6, 12.2)	10.2 (7.3, 13.1)
Income category, % (95% CI)					
Less than $10,000	14.5 (13.2, 15.8)	18.4 (16.5, 20.3)	8.7 (5.8, 11.6)	12 (7.4, 16.5)	7.3 (5.6, 9)
$10,001-$20,000	32.1 (30.2, 34.0)	34.8 (32.6, 36.9)	29.7 (24.3, 35)	28.1 (22.5, 33.6)	27.4 (23.1, 31.7)
$20,001-$40,000	33.5 (31.6, 35.3)	32.5 (30.1, 34.8)	34.4 (29.1, 39.6)	35 (28.9, 41)	35.3 (31.1, 39.5)
$40,001-$75,000	14.5 (13.0, 15.9)	10.9 (9.6, 12.2)	21.7 (16.6, 26.9)	17.4 (12.7, 22)	20.1 (16.4, 23.9)

More than $75,000	5.5 (4.3, 6.6)	3.5 (2.7, 4.3)	5.5 (3.1, 7.9)	7.6 (3.5, 11.8)	10 (7, 13)
AHEI Score, mean (95% CI)	47.9 (47.6, 48.3)	47.6 (47.2, 48)	49.8 (49, 50.6)	49.5 (48.3, 50.6)	47.6 (46.9, 48.3)
Sedentary time (min/day), mean (95% CI)	480.7 (473.2, 488.1)	487.1 (478.1, 496.1)	458.8 (441.7, 476)	465.9 (448.1, 483.7)	476.5 (461.7, 491.3)
Accelerometer wear time (hrs), mean (95% CI)	15.9 (15.7, 16.0)	16 (15.8, 16.1)	15.6 (15.2, 15.9)	15.5 (15.2, 15.8)	15.8 (15.5, 16.1)
Cigarette use, % (95% CI)					
Never	63.3 (61.6, 65.1)	62 (59.9, 64.1)	63.5 (57.8, 69.2)	64.1 (58.2, 70.1)	66.4 (62.2, 70.6)
Former	17.9 (16.7, 19.1)	19.1 (17.5, 20.7)	20.1 (15.5, 24.7)	17.3 (13.4, 21.3)	14.1 (11.7, 16.5)
Current	18.8 (17.1, 20.4)	18.9 (17.2, 20.6)	16.4 (11.9, 21)	18.5 (12.8, 24.3)	19.5 (15.5, 23.5)
Alcohol use level, % (95% CI)					
No use	50.2 (48.1, 52.3)	55.5 (53.2, 57.8)	41.4 (35.7, 47.2)	45.5 (39.3, 51.7)	41 (36.9, 45.1)
Low risk	44.6 (42.5, 46.6)	39.7 (37.5, 41.9)	52.4 (46.5, 58.2)	51.9 (45.7, 58.2)	52.1 (47.9, 56.3)
High risk	5.2 (4.4, 6.1)	4.8 (3.9, 5.7)	6.2 (3.2, 9.1)	2.5 (1, 4)	7 (4.5, 9.5)
BMI, mean (95% CI)	29.5 (29.3, 29.7)	30.7 (30.3, 31.2)	29.7 (29.3, 30.1)	29.4 (29, 29.9)	28.3 (27.9, 28.7)
Waist-to-Hip Ratio, mean (95% CI)	0.9 (0.9, 0.9)	0.9 (0.9, 0.9)	0.9 (0.9, 0.9)	0.9 (0.9, 0.9)	0.9 (0.9, 0.9)
eGFR, mean (95% CI)	110.0 (109.3, 110.8)	108.2 (107.3, 109.1)	111.8 (109.9, 113.7)	107.9 (105.1, 110.6)	115 (113.7, 116.3)
Urine ACR, mean (95% CI)	24.6 (21.3, 27.8)	29 (24.3, 33.6)	18.9 (12.4, 25.4)	15.8 (12.2, 19.4)	18 (11.4, 24.6)
CRP, mean (95% CI)	3.9 (3.6, 4.2)	4.5 (4.1, 4.9)	3 (2.6, 3.3)	3.7 (3.1, 4.3)	2.7 (2.4, 3)
Hypertension (Yes), % (95% CI)	22.6 (21.1, 24.1)	26.4(24.5, 28.3)	18.1(14.4, 21.8)	23.3(19.1, 27.5)	13.7(11.3, 16.1)
Diabetes (Yes), % (95% CI)	15.6 (14.5, 16.8)	18.7(17.2, 20.1)	13.6(10.2, 17)	17.2(12.6, 21.9)	7.7(6, 9.5)
Cardiovascular Disease (Yes), % (95% CI)	23.3 (21.8, 24.7)	26.5(24.7, 28.3)	17.5(14.1, 21)	28.4(22.8, 34)	15.1(11.7, 18.5)

ACEI use, % (95% CI)	8.7 (7.9, 9.6)	10.5(9.4, 11.6)	6(4.2, 7.9)	9.1(6.6, 11.7)	4.8(3.4, 6.3)
ARB use, % (95% CI)	3.6 (3.1, 4.1)	4.1 (3.5, 4.6)	4.1 (2, 6.3)	6.2 (3.6, 8.9)	1.3 (0.6, 2)

S2. Table 1. Baseline Characteristics, by Quartiles of Accelerometer-Measured MVPA

	Total	Q1 (0 - 39.6 min/wk)	Q2 (39.7 - 103.6 min/wk)	Q3 (103.7 - 219.3 min/wk)	Q4 (219.5+ min/wk)
Variable	**N=8,073**	**N=2030**	**N=2010**	**N=2017**	**N=2016**
Age (yrs), mean (95% CI)	42.5 (41.8, 43.1)	49.2 (48, 50.5)	42.7 (41.7, 43.7)	40.7 (39.8, 41.6)	38.3 (37.3, 39.3)
Women, % (95% CI)	55.7 (54.0, 57.4)	69 (65.9, 72.2)	63.4 (59.7, 67.1)	51.6 (48.4, 54.8)	41.6 (38.3, 44.9)
Center, % (95 %CI)					
Bronx	25.7 (22.7, 28.6)	14.3 (11.1, 17.4)	19.1 (14.4, 23.8)	26.8 (22.9, 30.6)	39.9 (35.4, 44.3)
Chicago	17.6 (15.3, 19.9)	13.6 (10.7, 16.5)	19.2 (16, 22.4)	19.1 (16, 22.1)	18.2 (15.4, 21)
Miami	29.6 (25.3, 34.0)	46 (40, 52)	33.4 (27.7, 39.1)	24.6 (19.7, 29.5)	17.3 (13.7, 20.9)
San Diego	27.1 (23.4, 30.9)	26.1 (21.3, 31)	28.3 (23.4, 33.3)	29.6 (24.5, 34.7)	24.7 (20.6, 28.7)
Born in the US, % (95% CI)	20.0 (18.2, 21.9)	13.1 (10.4, 15.7)	17.4 (14.1, 20.6)	21 (18, 24.1)	27.2 (24, 30.4)
Hispanic/Latino Background, % (95% CI)					
Dominican	9.3 (7.6, 11.0)	5.1 (3.7, 6.5)	9 (4.6, 13.4)	10.5 (8.3, 12.7)	11.9 (9.3, 14.5)
Central American	7.3 (6.1, 8.5)	6 (4.7, 7.3)	7.1 (5.4, 8.8)	8.4 (6.4, 10.3)	7.5 (5.8, 9.3)
Cuban	21.0 (17.5, 24.6)	36.2 (30.7, 41.8)	25.3 (20.3, 30.3)	15 (11.3, 18.7)	10 (7.6, 12.4)
Mexican	39.7 (36.1, 43.3)	31.8 (27.3, 36.4)	40.3 (35.2, 45.5)	43.7 (38.7, 48.6)	42.1 (38, 46.2)
Puerto Rican	14.7 (12.9, 16.5)	13.5 (10.5, 16.5)	11.3 (9.2, 13.3)	14.1 (11.6, 16.7)	19.2 (16.2, 22.2)
South American	4.9 (4.1, 5.6)	3.9 (2.8, 4.9)	4.5 (3.4, 5.6)	5.6 (4.2, 6.9)	5.4 (4.1, 6.7)
More than one/Other	3.1 (2.5, 3.8)	3.4 (1.8, 5)	2.5 (1, 3.9)	2.8 (1.7, 3.9)	3.8 (2.5, 5.1)
Preferred language: Spanish, % (95% CI)	77.7 (75.7, 79.8)	85.6 (82.6, 88.6)	81.7 (78.5, 84.9)	75.3 (72, 78.5)	70 (66.5, 73.5)

Education, % (95% CI)					
Less than high school	31.4 (29.5, 33.3)	33.9 (30.5, 37.2)	28.7 (25.5, 32)	32.1 (28.9, 35.3)	31.2 (28, 34.3)
High school/GED	27.4 (25.6, 29.1)	24.7 (21.5, 27.8)	29.3 (24.8, 33.8)	25.7 (22.8, 28.6)	29.5 (26.2, 32.8)
Greater than high school/GED	41.2 (39.1, 43.3)	41.5 (38, 45)	42 (37.9, 46)	42.2 (38.5, 45.9)	39.4 (35.5, 43.2)
Homemaker, % (95% CI)	44.7 (43.0, 46.4)	54.9 (51.7, 58.1)	50.4 (46.3, 54.5)	43.1 (39.9, 46.2)	32.7 (29.8, 35.7)
Employment status, % (95% CI)					
Retired and not employed	8.8 (7.8, 9.8)	16 (13.7, 18.4)	8.7 (6.7, 10.7)	6.5 (5.1, 7.8)	4.9 (3.7, 6.1)
Not retired and not employed	40.0 (38.1, 41.8)	44.7 (41.4, 48)	42.8 (38.5, 47.1)	37.9 (34.7, 41.2)	35.5 (32.1, 38.8)
Part-time	17.4 (16.1, 18.6)	12.9 (10.6, 15.1)	16.8 (14.2, 19.3)	17.5 (15.1, 19.9)	21.5 (18.9, 24.1)
Full-time	33.9 (32.3, 35.4)	26.4 (23.1, 29.7)	31.7 (28.4, 35)	38.1 (34.7, 41.5)	38.1 (34.9, 41.3)
Current Employment, % (95% CI)					
Not employed	48.7 (46.8, 50.6)	60.7 (57.1, 64.2)	51.5 (47.4, 55.5)	44.4 (41, 47.8)	40.4 (37, 43.7)
Non-skilled worker	13.8 (12.6, 15.1)	8.2 (6.7, 9.7)	13.9 (11.6, 16.2)	14.9 (12.6, 17.2)	17.6 (14.9, 20.2)
Service worker	10.2 (9.0, 11.4)	9.1 (7.3, 10.9)	10.1 (7.9, 12.2)	10.6 (8.6, 12.7)	10.8 (8.7, 13)
Skilled worker	11.6 (10.5, 12.7)	9.3 (7.3, 11.3)	10.4 (8.2, 12.6)	12.3 (10.3, 14.3)	14 (11.8, 16.3)
Professional/administrative	6.6 (5.6, 7.6)	5.6 (4.1, 7)	5.5 (4.1, 6.9)	8 (5.7, 10.3)	7 (5.4, 8.6)
Other occupation	9.0 (7.8, 10.2)	7.2 (4.7, 9.6)	8.7 (6.7, 10.6)	9.7 (7.8, 11.7)	10.2 (7.8, 12.6)
Income category, % (95% CI)					
Less than $10,000	14.5 (13.2, 15.8)	16.1 (13.7, 18.5)	13.9 (11.6, 16.2)	13.4 (11, 15.8)	14.7 (12.3, 17.1)
$10,001-$20,000	32.1 (30.2, 34.0)	34.5 (31.3, 37.8)	34.4 (30.9, 37.8)	29.4 (26.3, 32.5)	30.6 (27.3, 33.9)
$20,001-$40,000	33.5 (31.6, 35.3)	32.5 (29.3, 35.6)	33.8 (29.5, 38.1)	36 (32.9, 39.1)	31.7 (28.4, 35.1)
$40,001-$75,000	14.5 (13.0, 15.9)	12.8 (10.6, 15)	13.9 (11.3, 16.5)	14.9 (12.2, 17.6)	15.9 (13.2, 18.6)

More than $75,000	5.5 (4.3, 6.6)	4.1 (2.6, 5.5)	4.1 (2.8, 5.4)	6.3 (3.7, 8.9)	7.1 (5.2, 9)
AHEI 2010 Score, mean (95% CI)	47.9 (47.6, 48.3)	47.8 (47.3, 48.4)	47.9 (47.2, 48.5)	48.2 (47.7, 48.8)	47.8 (47.3, 48.4)
Sedentary time (min/day), mean (95% SI)	480.7 (473.2, 488.1)	493.9 (482.2, 505.7)	476.7 (463.4, 490)	480.8 (468.7, 493)	473 (461, 485)
Accelerometer wear time (hrs), mean (95% CI)	15.9 (15.7, 16.0)	14.9 (14.6, 15.1)	15.4 (15.2, 15.6)	16.1 (15.8, 16.3)	16.9 (16.7, 17.1)
Cigarette use, % (95% CI)					
Never	63.3 (61.6, 65.1)	57.6 (54.2, 61)	64.4 (60.9, 67.9)	64.9 (61.6, 68.2)	65.7 (62.6, 68.8)
Former	17.9 (16.7, 19.1)	23.9 (21, 26.7)	15.9 (13.7, 18.1)	17.2 (14.9, 19.6)	15.3 (13.2, 17.3)
Current	18.8 (17.1, 20.4)	18.5 (15.4, 21.6)	19.7 (16.5, 22.9)	17.9 (14.7, 21.1)	19 (16.2, 21.8)
Alcohol use level, % (95% CI)					
No use	50.2 (48.1, 52.3)	58 (54.3, 61.6)	52 (47.9, 56)	46.7 (42.9, 50.6)	45.3 (41.9, 48.8)
Low risk	44.6 (42.5, 46.6)	37 (33.6, 40.5)	43.1 (39.3, 46.9)	47.8 (43.8, 51.8)	49.2 (45.6, 52.7)
High risk	5.2 (4.4, 6.1)	5 (2.7, 7.3)	4.9 (3.6, 6.3)	5.4 (3.8, 7.1)	5.5 (4.1, 6.9)
BMI, mean (95% CI)	29.5 (29.3, 29.7)	30.8 (30.3, 31.2)	29.7 (29.2, 30.1)	29.5 (29, 30)	28.4 (28, 28.7)
Waist-to-Hip Ratio, mean (95% CI)	0.9 (0.9, 0.9)	0.9 (0.9, 0.9)	0.9 (0.9, 0.9)	0.9 (0.9, 0.9)	0.9 (0.9, 0.9)
eGFR, mean (95% CI)	110.0 (109.3, 110.8)	102.6 (101.2, 104)	110.6 (109.4, 111.8)	111.6 (110.4, 112.7)	114.3 (113.2, 115.5)
Urine ACR, mean (95% CI)	24.6 (21.3, 27.8)	34.7 (26.3, 43.2)	23.1 (16, 30.2)	24.7 (17.9, 31.6)	17.3 (13.7, 20.9)
CRP, mean (95% CI)	3.9 (3.6, 4.2)	4.8 (4.4, 5.2)	4.3 (3.5, 5.2)	3.7 (3.3, 4)	3 (2.7, 3.2)
Hypertension (Yes), % (95% CI)	22.6 (21.1, 24.1)	34.9 (32, 37.7)	22.4 (19.7, 25.2)	19.8 (17.6, 22.1)	14.9 (12.9, 17)
Diabetes (Yes), % (95% CI)	15.6 (14.5, 16.8)	25.5 (22.7, 28.3)	15.4 (13.3, 17.4)	13.9 (11.7, 16.1)	9.2 (7.7, 10.6)
Cardiovascular Disease (Yes), % (95% CI)	23.3 (21.8, 24.7)	33.6 (30.3, 36.9)	21.9 (19.5, 24.2)	21.3 (18.5, 24.2)	17.6 (15.1, 20.1)

ACEI use, % (95% CI)	8.7 (7.9, 9.6)	13.2 (11.3, 15.1)	9.6 (7.7, 11.4)	7.4 (6.1, 8.7)	5.4 (4.3, 6.6)
ARB use, % (95% CI)	3.6 (3.1, 4.1)	6.4 (5.1, 7.8)	3.5 (2.6, 4.5)	3 (2.1, 3.9)	1.8 (1.2, 2.4)