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Sedentary Behavior in Individuals with Diabetic Chronic Kidney Disease and Maintenance Hemodialysis

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Abstract

Objective—Examine whether more advanced kidney failure is associated with sedentary behavior and whether demographics, comorbidity, nutritional and inflammatory markers explain this association.

Design—Observational Study

Setting—Outpatients recruited from outpatient clinics and dialysis units

Subjects—160 patients with CKD or receiving MHD

Methods—Standardized questionnaires including Baecke physical activity questionnaire, standardized anthropometry examination and blood draw.

Main outcome measures—Sedentary behavior (defined as answering "very often" for "During leisure time I watch television" or answering "never" for "During leisure time I walk") and being physically active (top 25th percentile of the total Baecke score)

Results—18.5% of CKD and 50.0% of MHD patients were sedentary ($p < 0.001$) and 38.8% of CKD and 11.3% of MHD patients were physically active. In separate multivariable logistic regression models, compared to CKD patients, MHD patients were more sedentary (OR 3.84, 95% CI 1.18 to 12.51) and less physically active (OR 0.07, 95% CI 0.01 to 0.40) independent of demographics, comorbidity, smoking, body size, serum hsCRP and albumin. Congestive heart failure, peripheral vascular disease and higher BMI were independently associated with sedentary behavior whereas younger age, lower BMI, lower serum hsCRP and higher serum albumin were associated with being physically active.

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Conclusions—Sedentary behavior is highly prevalent among diabetic CKD or MHD patients. The strong association of MHD status with sedentary behavior is not explained by demographics, smoking, comorbidity, nutritional and inflammatory markers. Interventions targeting obesity might improve sedentary behavior and physical activity whereas interventions targeting inflammation might improve physical activity in these populations.

Keywords

chronic kidney disease; maintenance hemodialysis; sedentary behavior; physical activity

Introduction

Basal metabolic rate (BMR) is the amount of energy expended while sitting quietly. Physical activity intensity could be defined using the metabolic intensity equivalent (MET), the ratio of the energy expended during an activity to the energy expended at rest[1]. Hence, 1 MET is the energy expenditure while sitting quietly. Sedentary behavior is engaging in "any waking activity characterized by an energy expenditure ≤ 1.5 metabolic equivalents *and* a sitting or reclining posture"[2].

Much of the focus on physical activity in chronic kidney disease (CKD) and the dialysis population has been on decreased physical function[3–5] and lower levels of moderate/vigorous physical activities (MVPA)[6–7]. More recently, sedentary behavior (defined by sitting time[8], television viewing time[9], pedometer[10] or accelerometer[11]) in CKD has been examined in cross-sectional studies. However, it is unclear whether uremia per-se is a risk factor for sedentary behavior. Furthermore, understanding the risk factors for sedentary behavior in CKD and dialysis patients would help in devising interventional trials targeting sedentary behavior in these populations.

Baecke questionnaire[12], a measure of habitual physical activity includes questions about household activities, sports, and leisure time activities. It has been found to be fairly accurate in identifying individuals with low energy expenditure when compared to the gold standard of doubly labeled water method [13]. We used the Baecke questionnaire to define sedentary behavior in CKD and maintenance hemodialysis (MHD) patients and examined the hypothesis that the greater prevalence of sedentary behavior in advanced kidney failure is independent of comorbidity, nutritional and inflammatory markers. We also examined the factors associated with sedentary behavior in CKD and maintenance hemodialysis (MHD) populations.

Methods

The current study is a secondary analysis of 80 CKD and 80 chronic MHD participants with type 2 diabetes recruited for three studies. The CKD participants were included from the "Effects of Febuxostat on Adipokines and Kidney Disease in Diabetic CKD" study (NCT01350388). In brief, that study was a randomized controlled trial to determine whether febuxostat therapy in overweight or obese, diabetic CKD patients and high serum uric acid levels impacts adipokines and markers of urinary fibrosis. The MHD population was comprised of 30 participants from the "Protein intake, nutrition, and cardiovascular disease in stage V CKD" study (NCT00566670), and 50 participants from the "Dialysis Registry" study (NCT02023528). The dialysis studies were observational studies. Details of these studies including the inclusion and exclusion criteria are available at clinicaltrials.gov. All studies were approved by the appropriate Institutional Review Board.

Participants included in the current study were: >18 years of age; diagnosed with either CKD (eGFR < 60mL/min/1.73m^2 or eGFR 60 to <90 mL/min/1.73m^2 with albuminuria), or stage 5 CKD on MHD; diagnosed with type 2 diabetes; completed the Baecke Physical Activity Questionnaire and had other relevant data available for this analysis. All participants underwent standardized study procedures conducted by the same team of trained study personnel.

Physical activity was assessed with the Baecke questionnaire[12], a reliable and validated[13–14] measure of habitual physical activity. It was administered at baseline in the interventional CKD study and the observational dialysis registry study. Television viewing time has been used as a measure of sedentary behavior[9, 15]. As sedentary behavior is engaging in activities that barely raise energy expenditure above the BMR, we defined sedentary behavior as answering "very often" for "During leisure time I watch television" or answering "never" for "During leisure time I walk". In additional analyses, we also examined the occupation/ work, sports, and leisure time activity indices derived from the Baecke questionnaire[12].

Statistical Analysis

There were 160 participants included in the analysis. Descriptive statistics for continuous variables are shown as mean ± standard deviation or medians with 25th and 75th percentiles and categorical variables are presented as percentages. Baseline characteristics between diabetic CKD and MHD participants were compared by two-tailed Student's t test or Wilcoxon rank-sum test for continuous variables and Chi-squared test or Fisher exact test for categorical variables.

In order to examine whether the risk of sedentary behavior is higher in MHD participants compared to CKD patients, unadjusted associations of MHD status with sedentary behavior was first examined in a logistic regression model. The extent to which this association was further attenuated by demographics (age, gender, race and education), comorbidity (history of coronary artery disease, coronary heart failure, peripheral vascular disease, stroke and hypertension), smoking, and body size and laboratory parameters (hsCRP and serum albumin) was examined by adding serially these groups of factors into the above logistic model. Serum hsCRP was heavily skewed and therefore, hsCRP was log transformed and then divided by the logarithm of 2; the results are expressed as the increase in the odds ratios for every 2-fold increase in hsCRP.

Furthermore, unadjusted and adjusted associations of the above factors with sedentary behavior were examined in logistic regression models.

Summation of the Baecke household score, sport score, and leisure time activity score resulted in a continuous overall unitless activity score. We classified those in the top 25th percentile of the overall score as physically active and examined the associations of MHD vs. CKD status with Baecke overall activity score ≥ 7.375 (75^{th} percentile) in logistic regression models similar to those described above for sedentary behavior. All statistical analyses were conducted by using Stata (version 12).

Results

Demographic and clinical characteristics of the entire cohort and the CKD and MHD subgroups are described in Table 1. Compared to the MHD participants, those with CKD were older and had higher BMI. However, the MHD participants still had higher prevalence of cardiovascular conditions, higher CRP levels and lower albumin levels.

As shown in Figure 1, the frequency of sedentary behavior was greater in the MHD population. Compared to the CKD subgroup, MHD subgroup had 4.33 fold higher odds (95% CI, 2.13 to 8.83) of being classified as sedentary unadjusted for other factors (Figure 2). Even after further adjustment for demographics (model 2 in Figure 2) or comorbidity and BMI (model 3 in Figure 2) or serum albumin and CRP (model 4 in Figure 2), MHD patients had greater than 3.8 fold higher odds of being sedentary (OR 3.84, 95% CI 1.18 to 12.51 in model 4 in Figure 2).

The associations of other factors with sedentary behavior in the entire cohort are summarized in Table 2. Reflecting the younger age and lower education level of the MHD sub-group, unadjusted, these two factors were associated with sedentary behavior. However, they were no longer significant in the adjusted models. Congestive heart failure and peripheral vascular disease were strongly associated with sedentary behavior in unadjusted and adjusted models (Table 2), albeit the confidence intervals were wider in the adjusted models. Higher BMI was associated with greater odds of sedentary behavior in both unadjusted and adjusted models. On the other hand, hypertension and higher serum albumin was associated with lower odds of sedentary behavior in only the unadjusted model.

The possible range of scores for each of the Baecke physical activity indices is from 1 to 5. Baecke physical activity indices by the CKD and MHD subgroups are summarized in Table 3. The differences in physical activity between the CKD and MHD participants were highest in the work index followed by the sports index. The MHD group also reported lower levels of leisure time activities as well.

As shown in Figure 3, the distribution of the total Baecke score in the non-CKD and CKD participants were significantly different (median (25^{th} – 75^{th} percentiles) 6.88 (6.13 –8.25) vs. 5.25 (4.50 –6.25), $p < 0.001$). Unadjusted, the MHD group had 80% lower odds of being physically active (defined as ≥ 75 percentile of the total Baecke activity score) as shown in Figure 4. This relationship was further strengthened when adjusted for demographics, comorbidity, serum hsCRP and albumin (Figure 4). In the multivariable logistic regression model, younger age, lower BMI, lower serum hsCRP and higher serum albumin were associated with higher odds of being physically active (Table 4).

Discussion

The results of this study indicate that compared to diabetic CKD patients, sedentary behavior is more prevalent in diabetic MHD patients and this is independent of comorbidity and markers of nutrition and inflammation. Furthermore, congestive heart failure, peripheral vascular disease and higher BMI are associated with sedentary behavior in this diabetic CKD and MHD cohort. While MHD patients are also less likely to be physically active, the factors that are associated with being physically active are different from sedentary behavior; younger age, absence of coronary artery disease, lower serum hsCRP and higher serum albumin are associated with higher odds of being physically active.

The Physical Activity Guidelines for Americans recommends at least 150 min/week of moderate intensity activity or 75 min/week of vigorous intensity activity[16]. However, 2.5 hrs/ week of moderate/ vigorous physical activity (MVPA) is only about 2% of total awake time (assuming awake time of 16 hrs/day or 112 awake hrs/ week). Hence, even if the weekly MVPA goals are achieved, one might still spend the majority of wake hours in sedentary activities. Indeed, in 91 healthy women, aged 40–75 years, in whom physical activity was measured objectively with an accelerometer for 1 week, total time spent sitting was not different between those who reached the MVPA goals versus those who did not[17]. Moreover, in 4066 Australian adults who reported at least 2.5 hrs per week of MVPA, significant, detrimental dose-response associations of television-viewing time were observed with waist circumference, systolic blood pressure, and 2-h plasma glucose [22]. Furthermore, increase in sedentary activity duration was associated with increased mortality independent of MVPA in the US general population [19]. Hence, sedentary behavior is not merely the absence of MVPA and achieving MVPA goals does not make one non-sedentary. Therefore, addressing sedentary behavior likely needs a different approach than simply prescribing MVPA goals.

Higher levels of physical activity and lower levels of sitting time as assessed by a questionnaire were associated with a lower prevalence of CKD independently of each other and other risk factors in a cross-sectional study [8]. In another study of community dwelling adults, total and light physical activities, measured objectively with an accelerometer, were found to be positively associated with kidney function [11]. Television viewing time was associated with albuminuria and low eGFR in another study[9]. The current study results indicate that compared to non-dialysis dependent diabetic CKD patients, diabetic MHD patients are > 3 fold higher risk of being sedentary.

This strong association is not explained by demographics, comorbidity, body size, serum albumin or CRP levels. External barriers such as lack of money and access to transport as well as internal barriers such as lack of motivation and time might play important role in sedentary behavior[20]. Furthermore, in MHD patients, post-dialysis fatigue[21] as well as anemia might be important contributors to sedentary behavior. It is also conceivable that inactivity and watching television during dialysis sessions might further induce sedentary behavior. It is also possible that factors such as peripheral vascular disease might also be mediators of the associations of uremia with sedentary behavior. Further studies are warranted to understand the relative role of these factors in sedentary behavior in MHD patients.

We noted significant associations of congestive heart failure, peripheral vascular disease, and higher BMI with sedentary behavior. It is possible that these associations are bi-directional, i.e., they are probably the causes and consequences of sedentary behavior. Therefore, interventions that target sedentary behavior might impact on cardiovascular disease in CKD and MHD patients.

In this study, based on the Baecke questionnaire, we defined sedentary behavior as "very often" watching television or "never" walking during leisure time, as prolonged television viewing or prolonged sitting time has been associated with increased risk of obesity[22–23], metabolic syndrome[23–24], diabetes[15, 23, 25–26], cardiovascular and all-cause mortality[23, 27–28]. In the current study, we observed an association of sedentary behavior with congestive heart failure, peripheral vascular disease and higher BMI suggesting internal face validity of our definition of sedentary behavior. This simple two question tool based on the frequency of watching television and the frequency of walking during leisure time is easily adaptable in busy clinical practice for screening for sedentary behavior.

It is of interest that the factors associated with sedentary behavior (Table 2) are different from the factors associated with being physically active (Table 4). Of note, higher BMI is associated with both sedentary behavior and lower physical activity whereas lower CRP and higher serum albumin were associated with being physically active. We speculate that anti-inflammatory interventions might improve physical activity in CKD and MHD patients.

The clinical implications of these findings are that as sedentary behavior is much more common in hemodialysis patients, clinicians should take advantage of the frequent interactions with these patients and emphasize the importance of increased physical activity.

The limitations of the current study include the cross-sectional nature of the study that limits causal inferences. No data on physical activities before the onset of dialysis were available. Furthermore, objective measurements of physical activity were not obtained.

In summary, MHD patients are at higher risk of sedentary behavior independent of comorbidity and markers of nutrition and inflammation. Furthermore, sedentary behavior is associated with higher BMI and cardiovascular disease in CKD and dialysis populations. A simple two question tool of frequency of watching television and frequency of leisure time walking could potentially identify sedentary behavior in this high risk population. Further studies are warranted to determine whether modifying sedentary behavior reduces cardiovascular risk in CKD and MHD patients.

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Practical Application

1. Sedentary behavior is much more common in hemodialysis patients
2. Clinicians should take advantage of the frequent interactions with these patients and emphasize the importance of increased physical activity.

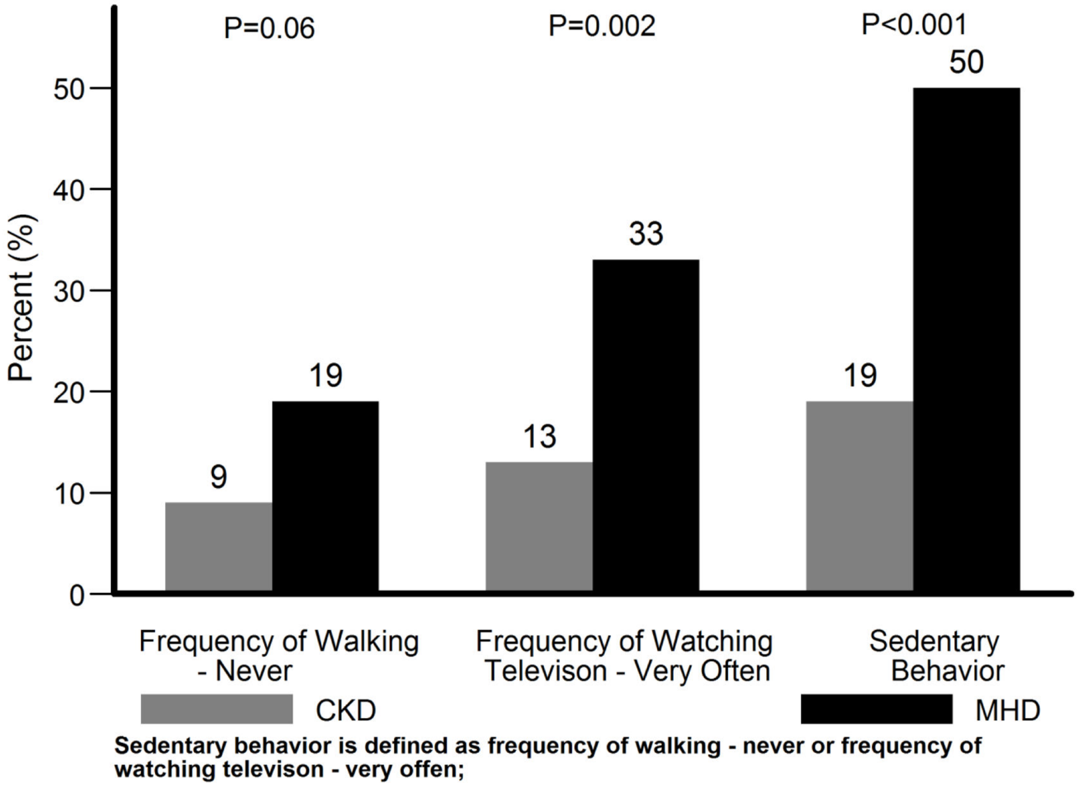

Figure 1.

Frequency of sedentary behavior in diabetic CKD and MHD patients

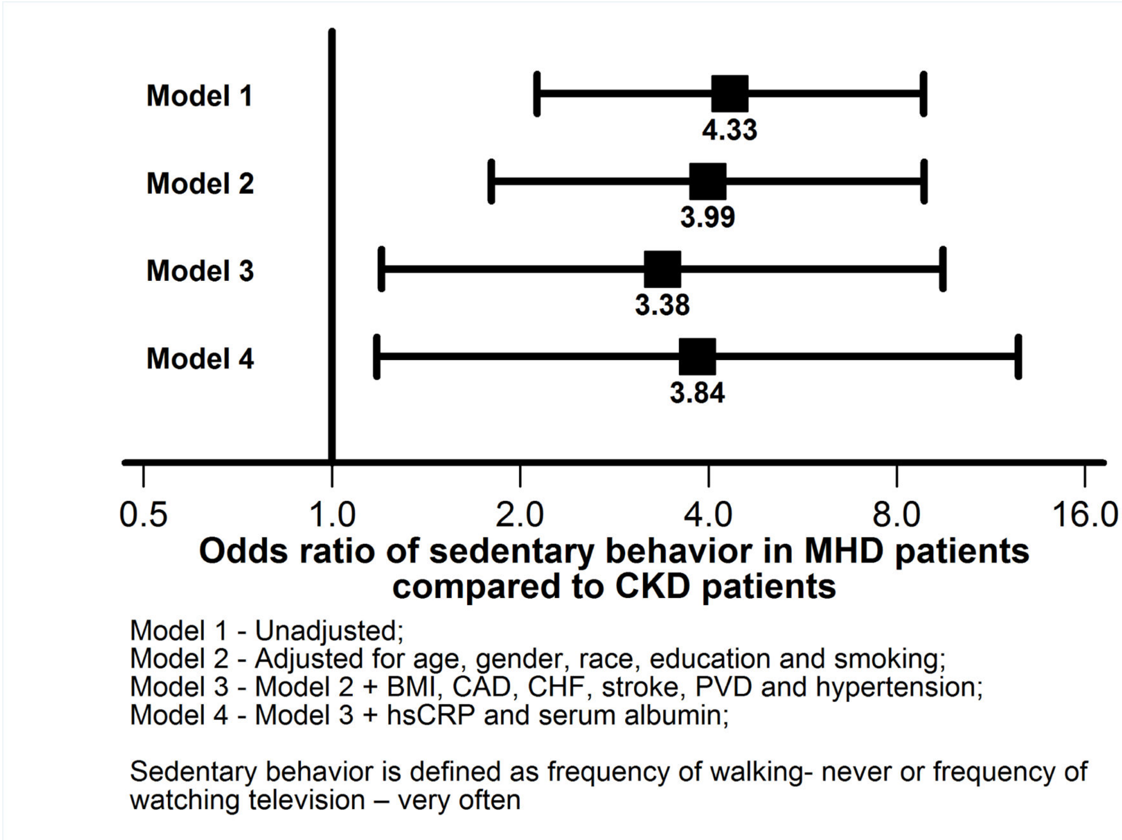

Figure 2.

Associations of MHD vs. CKD status with sedentary behavior in logistic regression models

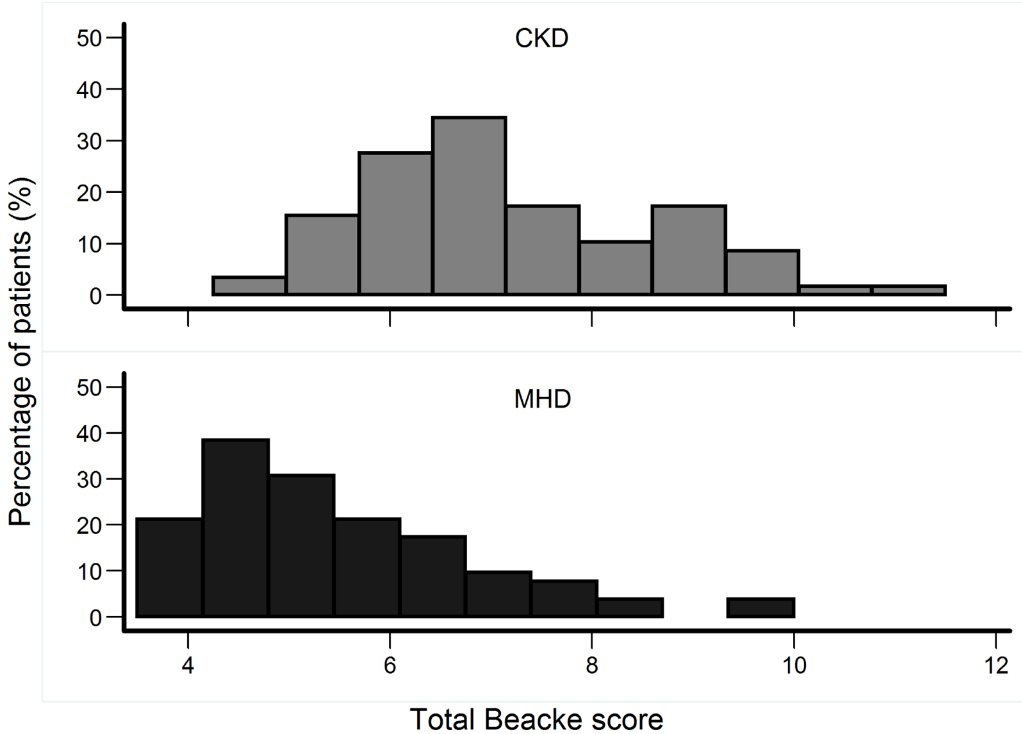

Figure 3.

Distribution of the total Baecke score in diabetic CKD and MHD patients

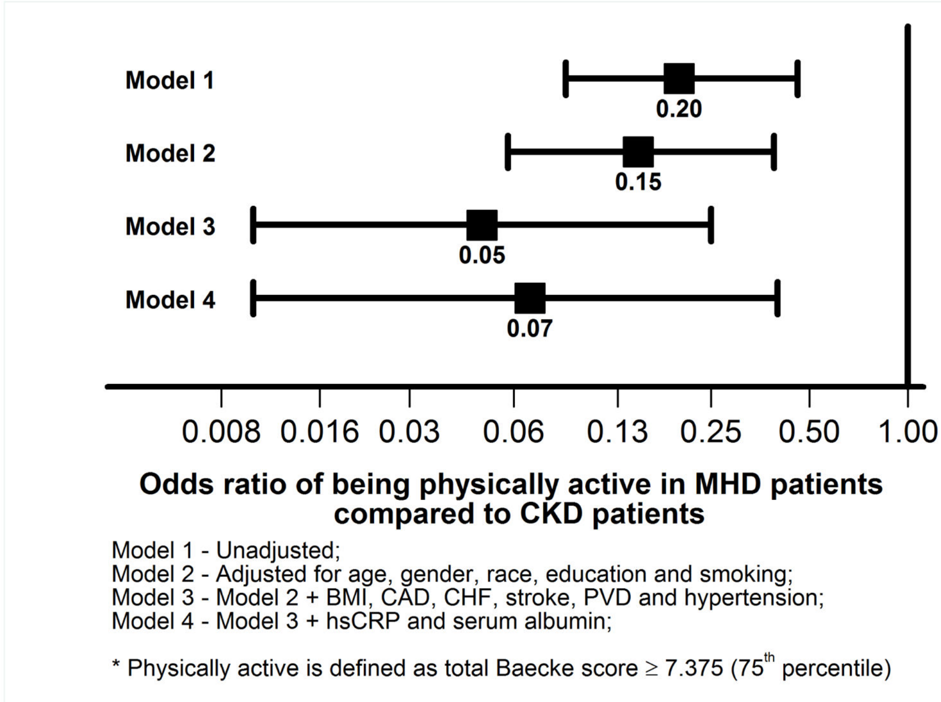

Figure 4.

Associations of MHD vs. CKD status with being physically active in logistic regression models

Table 1

Demographics and clinical characteristics of the diabetic CKD and MHD participants

	All (n = 160)	CKD (n = 80)	MHD (n = 80)	p value
Age (years)	63.7 ± 12.5	67.6 ±10.9	59.6 ±12.9	<0.001
Male (%)	56.3%	53.8%	58.8%	0.52
Black race (%)	4.4%	3.8%	5.0%	0.70
Education less than college (%)	31.9%	17.5%	46.3%	<0.001
Body mass index (kg/m^2)	33.0 ± 7.7	34.4 ± 6.8	31.6 ± 8.4	0.02
Smoking (%)	31.9%	36.3%	27.5%	0.24
Coronary artery disease (%)	28.1%	17.5%	38.8%	0.003
Congestive heart failure (%)	21.3%	10.0%	32.5%	0.001
Peripheral vascular disease (%)	20.0%	3.8%	36.3%	<0.001
Stroke (%)	11.9%	3.8%	20.0%	0.001
Hypertension (%)	80.0%	76.3%	83.8%	0.24
Serum hsCRP (mg/L)	3.0 (1.5, 6.4)	2.2 (1.2, 4.5)	4.6 (2.0, 8.6)	0.001
Serum albumin (g/dL)	3.9 ± 0.4	4.1 ± 0.3	3.8 ± 0.5	<0.001
eGFR (ml/min/1.73 m^2)		54.7 ± 18.7	NA	

Table 2

Factors associated with sedentary behavior in univariate and multivariate logistic regression models in diabetic CKD and MHD patients

	Univariate models OR (95%CI)	**p**	**Multivariate model OR (95%CI)**	**p**
MHD vs. CKD	4.33 (2.13, 8.83)	<0.001	3.84 (1.18, 12.51)	0.03
Each SD ↑ in age*	0.73 (0.52, 1.01)	0.06	0.82 (0.52, 1.29)	0.38
Male gender	0.64 (0.33, 1.24)	0.19	0.54 (0.22, 1.34)	0.18
Black race	1.46 (0.31, 6.75)	0.63	0.77 (0.11, 5.26)	0.79
Education less than college	2.53 (1.27, 5.06)	0.01	1.37 (0.54, 3.50)	0.51
Smoking	1.20 (0.60, 2.41)	0.60	1.62 (0.62, 4.19)	0.32
Coronary artery disease	1.23 (0.60, 2.52)	0.57	0.57 (0.18, 1.75)	0.32
Congestive heart failure	4.37 (1.97,9.69)	<0.001	4.08 (1.27, 13.07)	0.02
Stroke	1.86 (0.71, 4.89)	0.21	0.73 (0.17, 3.13)	0.67
Peripheral vascular disease	4.43 (1.96,10.00)	<0.001	2.76 (0.88, 8.65)	0.08
Hypertension	2.69 (1.03, 7.00)	0.04	2.72 (0.78, 9.46)	0.12
Each SD↑ in BMI*	1.33 (0.96, 1.84)	0.09	1.78 (1.15, 2.75)	0.009
Each doubling of hsCRP	1.16 (0.96, 1.39)	0.13	0.88 (0.68, 1.13)	0.32
Each SD ↑ in serum albumin*	0.56 (0.38, 0.82)	0.003	0.79 (0.50, 1.26)	0.33

*Each SD of age = 12.5 (years); Each SD of BMI = 7.7 (kg/m^2); Each SD of serum albumin = 0.44 (g/dL)

Table 3

Summary of Baecke activity scores*

	CKD	MHD	P value**
Work index score	2.75 (2.38, 3.00)	1.00 (1.00, 1.94)	<0.001
Sports index score	1.75 (1.50, 2.25)	1.50 (1.25, 2.00)	0.02
Leisure index score	2.50 (2.00, 3.00)	2.25 (1.75, 2.75)	0.008

*Presented as median, 25th and 75th percentile.

**P-value by Wilcoxon rank-sum test.

Table 4

Factors associated with being physically active* in univariate and multivariate logistic regression models in diabetic CKD and MHD patients

	Univariate models OR (95%CI)	p	Multivariate model OR (95%CI)	p
MHD vs. CKD	0.20 (0.09, 0.46)	<0.001	0.07 (0.01, 0.40)	0.002
Each SD ↑ in age**	1.02 (0.71, 1.46)	0.93	0.57 (0.32, 1.03)	0.06
Male gender	1.41 (0.68, 2.94)	0.36	1.33 (0.49, 3.59)	0.58
Black race	2.35 (0.50, 10.99)	0.28	9.09 (1.06, 78.09)	0.04
Education less than college	0.73 (0.49, 1.09)	0.12	1.51 (0.50, 4.51)	0.46
Smoking	0.89 (0.41,1.94)	0.77	0.53 (0.19, 1.50)	0.23
Coronary artery disease	0.54 (0.23, 1.24)	0.15	0.80 (0.22, 2.92)	0.74
Congestive heart failure	0.56 (0.24, 1.33)	0.19	0.91 (0.20, 4.07)	0.90
Stroke	0.58 (0.22, 1.52)	0.27	1.07 (0.15, 7.92)	0.94
Peripheral vascular disease	0.32 (0.07, 1.45)	0.14	1.63 (0.35, 7.72)	0.54
Hypertension	0.49 (0.18, 1.38)	0.18	0.53 (0.17, 1.62)	0.27
Each SD↑ in BMI**	0.56 (0.24, 1.29)	0.17	0.42 (0.22, 0.80)	0.008
Each doubling of hsCRP	0.69 (0.54, 0.87)	<0.001	0.74 (0.55, 1.00)	0.052
Each SD ↑ in serum albumin**	2.75 (1.65, 4.59)	<0.001	1.89 (1.07, 3.34)	0.03

*Defined as total Baecke score ≥ 7.375 (75th percentile)

**Each SD of age = 12.5 (years); Each SD of BMI=7.7 (kg/m^2); Each SD of serum albumin=0.44 (g/dL)