Original Report:
Cardiovascular Disease
and Risk Factors

A Racial Comparison of Differences between Self-Reported and Objectively Measured Physical Activity among US Adults with Diabetes

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Objective: To investigate: 1) the racial/ethnic disparities in meeting the recommended physical activity as measured by subjective vs objective measures in a national sample of individuals with type 2 diabetes mellitus; and 2) the racial/ethnic differences with respect to the magnitude of the discrepancy between self-reported and objectively measured moderate-to-vigorous intensity aerobic physical activity (MVPA).

Methods: We used data from the National Health and Nutrition Examination Survey (NHANES) 2003-06 to calculate and compare the percentage of individuals with diabetes who achieved the recommended levels of physical activity as measured by subjective self-report (500 metabolic equivalents (MET)-minutes/week) and objective accelerometer measurement (150 minutes per week of MVPA) across racial/ethnic groups.

Results: 71.2%, 15.7%, and 13.1% of participants were White, African American, and Hispanic, respectively. Based on self-report, 67.1%, 39.2%, and 55.1% of Whites, African Americans, and Hispanics, respectively, met the 500 MET-minutes/week threshold of physical activity (P<.0001). Objective measurement by accelerometer showed that 44.2%, 42.6%, and 65.1% of Whites, African Americans, and Hispanics, respectively, met the threshold (P<.0003).

Conclusions: Many individuals with type 2 diabetes mellitus did not meet the recommended physical activity thresholds. African Americans had the lowest proportion of meeting both the self-reported and objectively measured thresholds. White patients with diabetes overestimated frequency of their physical activity, while their Hispanic counterparts significantly underestimated it. Also, the gap between the two measures of MVPA was largest among Hispanics. *Ethn Dis*. 2017;27(4):403-410; doi:10.18865/ed.27.4.403.

Keywords: Accelerometry; Ethnicity; Physical Activity; BMI; Diabetes; National Data

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Introduction

Type 2 diabetes mellitus is a metabolic disease of epidemic proportions in the United States,[1] but can be prevented and modified by regular physical activity (PA).[2-4] The American Diabetes Association guidelines[5] recommend that adults with type 2 diabetes perform at least 150 min/week of moderate-to-vigorous intensity aerobic physical activity (MVPA, defined as 50%–70% of the maximum heart rate), spread over at least 3 days/week with no more than 2 consecutive days without exercise.[5,6] However, despite the establishment of physical activity guidelines, data from the U.S. Centers for Disease Control and Prevention (CDC) reveals that 36.1% of US adults with diabetes report no physical activity within the previous 30 days.[7] In one study of pre-diabetic patients, prescription of at least 150 minutes of physical activity per week yielded 16% reduction in developing type 2 diabetes mellitus for every kilogram lost.[8] Also, structured physical exercise interventions of at least 8 weeks in duration have been found to lower hemoglobin A1c (HgbA1c) levels regardless of weight loss;[9] furthermore, physical activity may overcome the adverse effects of sedentariness.[10]

However, many of these prior studies lacked inclusion of non-White US populations,[11] which is particularly of concern since African American and Hispanic populations have a higher prevalence and dis-

ease burden of diabetes than their non-Hispanic White counterparts.[1,7] Joseph et al showed that, in a multiethnic cohort, the incidence of type 2 diabetes was inversely associated with the extent of physical activity, and varied with race/ethnicity.[11] However, most other studies lacked sufficient sample sizes of non-White race/ethnic groups.

In addition, most early studies estimated physical activity levels using self-reported surveys, which are prone to significant reporting bias, attributable to factors such as social desirability bias, inability to capture valuable contextual physical activity-related information,[12,13] as well as the cognitive challenges of accurately estimating frequency, intensity, and duration of physical activity.[14,15] Accelerometers were introduced to research in the 1980s to objectively measure physical activity, and their use has increased exponentially over time.[16] While both subjective and objective measures of physical activity have demonstrated cultural validity and reliability,[17] there is a clear discrepancy between these methods of measuring the physical activity of the US adult population.[18-20] This discrepancy also extends to comparisons between race/ethnic groups. For example, using data from the National Health and Nutrition Examination Survey (NHANES) 2005-06, Tucker et al showed that Mexican Americans had the lowest level of self-reported physical activity but the highest level of objectively measured physical activity, when compared with Whites and African Americans.[21] Previous studies comparing subjective and objective measures of physical activity also have not specifically focused on individuals with diabetes.

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In our study, we report racial/ethnic differences in meeting the recommended physical activity as measured by subjective self-report (500 metabolic equivalents (MET)-minutes/week) and objective accelerometer measurement (150 minutes per week of MVPA) among US adults diagnosed with type 2 diabetes mellitus. We also examine the racial/ethnic differences with respect to the magnitude of the discrepancy between self-reported and objectively measured MVPA.

Methods

Study Design and Sample

We conducted a cross-sectional study using data from the NHANES 2003-06.[22,23] We analyzed datasets from individuals who: 1) were aged ≥18 years and 2) had diabetes based on: a) physician-diagnosed diabetes mellitus; b) were taking insulin or oral diabetes medication(s); c) had a HgbA1c level > 6.5%; or d) had a fasting glucose level >126 mg/dL. We chose to use NHANES data from 2003-2004 and 2005-2006, since only during these two waves were accelerometers used to objectively measure physical activity, together with self-reported data, allowing for a direct comparison of physical activity using both methods.[14,19,24]

NHANES uses a multi-stage probability cluster sampling design to provide nationally representative data on a variety of health risks and behaviors. All counties within the United States served as the sampling frame for NHANES. Racial/ethnic group was a factor of selection. To increase the precision of estimates for certain subdomains, oversampling was carried out for adolescents (aged 12–19 years), older Americans (aged ≥60 years), Mexican American persons, and the Black population. In addition, in NHANES 2000–2006, pregnant women and all others at or below 130% of the poverty level were also oversampled.

The racial/ethnic groups comprised the following: Hispanic (including Mexican Americans), non-Hispanic White, non-Hispanic Black, and other non-Hispanic race/ethnicity including non-Hispanic multi-racial. We excluded other non-Hispanic race because of small sample size, and combined Mexican American and Other Hispanic as Hispanic group. We included only data from participants who had collected ≥4 days of calibrated accelerometer data, and had completed the physical activity questionnaire.

Measures/Variables

An Actigraph model 7164[21] was used by NHANES to collect objective MVPA data. Participants were instructed to wear the accelerometers over their right hip with an elastic band around their waist. The device was to be worn only during waking hours, and removed prior to sleep as well as during any activities causing it to be submerged in water. Devices were worn for up to 7 days and mailed back to the manufacturer to verify proper calibration. The accelerometer measured vertical acceleration as counts per minute (CPM), reflecting the intensity of movement. Participants were instructed to return the activity monitors by mail using the postage-paid padded envelopes provided; details about the return rate for the Actigraph were not available, but participants received $40 remuneration after their monitors were returned.

For self-reported data collection, surveys were available in both English and Spanish and were administered by bilingual staff, as appropriate. All activities surveyed were of at least moderate intensity (>3 METs, as referenced by the Compendium of Physical Activities).[19] The survey asked participants to estimate the frequency and duration of participation in a given activity within the past 30 days, and included specific activities such as running, basketball, baseball, etc. Importantly, all questions pertained to activities that were performed for at least 10 minutes in duration.

Outcome Variables

Self-report physical activity levels were calculated as MET-minutes. Total MET-minutes of physical activity were calculated by multiplying the physical activity volume (duration x frequency) of each activity per week by its corresponding MET value. Participants with 500 MET minutes/week or more were categorized as meeting the recommended guidelines.

Objectively measured MVPA was defined as >2,020 CPM,[17] with bouts of at least 10 minutes in duration, while also allowing for rest of up to 2 minutes below this threshold within each 10-minute bout.[21] We used the create.pam_perday.sas, SAS programs to convert NHANES 2003-2006 accelerometer (objective data) into weekly average using the following equation; $\sum$ [(# bouts per 30 days) x (duration of each bout) x (7/30)] for each of the queried activities. This program was developed by the Epidemiology and Genomics Research Program in the National Cancer Institute (http://epi.grants.cancer.gov/nhanes_pam/create.html).

The mean duration (minutes) of accumulated moderate and vigorous activity per day from all valid days (in which the participant wore the monitor for 10+ hours) was calculated, then multiplied by 7 to get a weekly average. The accelerometer outcome measure was computed to create a measure that would parallel the self-report MET-minute variable (METPA). Accelerometer counts were first converted into MET-minutes using a published equation developed for the Actigraph.[12]

Independent Variables

The study's main independent variable was race/ethnicity categorized as non-Hispanic Whites (White), non-Hispanic Blacks (AA), and Hispanics (Hispanic) as defined above. Other covariates were sex, age, income level, education level, BMI, and number of chronic diseases. To assess chronic conditions, participants were asked if they had ever been told by a doctor or other health professional if they had any of the following conditions: arthritis, coronary heart disease, stroke, congestive heart failure, myocardial infarction, emphysema, chronic bronchitis, asthma, and cancer. Responding "Yes" to any of the above conditions derived a binary variable (yes/no) for "any chronic disease."

Statistical Analyses

We conducted descriptive analyses to describe characteristics of the study population and bivariate analyses using chi-square tests or t-tests to determine the statistical difference in proportion of the participants who met MVPA in self-report and/or accelerometer measurement by racial/ethnic groups and other sample characteristics (sex, age, education level, BMI, and chronic conditions). We used unadjusted and adjusted modified Poisson Regression,[25] controlling for age, sex, education level, income level, and BMI (model 2), as well as the number of chronic conditions (model 3) to explore the independent associations between measures of physical activity and race/ethnicity groups. Statistical significance was indicated by $P<.05$, prevalence ratio (PR) and 95% CI. Data were analyzed using SAS (Release V.9.2, 2008; SAS, Inc.). Sample weights, provided by the National Center for Health Statistics, were used to correct for differential selection probabilities and to adjust for non-coverage and non-response.

Results

A total of 871 participants provided complete data that met all inclusion criteria for our study. Of the full study sample, 71.2%, 15.7%, and 13.1% were White, African American, and Hispanic, respectively. Slightly more than 50% were female, 60.6% were aged <65 years, and 55% were obese (Table 1). Based on self-report, 67.1%, 39.2%, and 55.1% of Whites, African Americans, and Hispanics, respectively, met the 500 MET-minutes/week threshold of physical activity (P<.0001, Table 2), and by accelerometer, 44.2%, 42.6%, and 65.1% of Whites, African Americans, and Hispanics, respectively, met the threshold (P<.0003). Table 2 also shows the associations of study variables with achievement of the recommended threshold. By self-report, being male and having an income >200% of federal poverty level (FPL) were significantly associated with achieving MVPA; and by accelerometer measures, being male, aged <65 years, having an income >200% of FPL, education ≥ high school, and absence of comorbid conditions were all significantly associated with achievement of the recommended threshold.

Table 1. Characteristic of the study sample

Variable	With ≥4 days accelerometer record in a week	Without ≥4 days accelerometer record in a week
	n (weighted %)	n (weighted %)
Race/ethnicity		
White	388 (71.2)	211 (69.0)
AA	231 (15.7)	137 (17.9)
Hispanic	252 (13.1)	118 (13.1)
Sex		
Male	457 (49.8)	222 (47.2)
Female	414 (50.2)	244 (52.8)
Age		
< 65	449 (60.6)	248 (63.3)
≥ 65	422 (39.4)	218 (36.7)
Income		
≤ 200% FPL	404 (38.7)	169 (51.4)
> 200% FPL	413 (61.3)	262 (48.6)
Education completed		
< High school	333 (25.8)	204 (29.8)
≥ High school	537 (74.2)	256 (70.2)
BMI		
< 25.0	142 (14.4)	57 (12.4)
25.0-29.9	280 (30.6)	116 (24.2)
≥ 30.0 kg/m^2	438 (55.0)	257 (63.4)
Prevalence of specific chronic diseases, n (weighted %)		
Arthritis	395 (45.1)	228 (48.2)
CHD	85 (10.0)	55 (10.6)
MI	99 (10.5)	66 (12.0)
CHF	91 (9.9)	62 (10.4)
Stroke	76 (8.1)	63 (10.6)
Emphysema	24 (2.9)	25 (4.8)
Chronic bronchitis	73 (9.9)	49 (10.3)
Asthma	107 (13.5)	64 (15.2)
Cancer	110 (13.7)	70 (15.5)
Any chronic disease above	556 (63.8)	315 (67.5)
Vegetarian diet	36 (4.6)	20 (4.3)
DM medication	453 (66.0)	239 (61.6)

AA, African American; BMI, body mass index; CHD, coronary heart disease; CHF, congestive heart failure; DM, diabetes mellitus; FPL, federal poverty level; MI, myocardial infarction.

As depicted in Figure 1, Y-axis, Whites had the highest self-reported MVPA estimate (ie, the frequency of MET minutes per week), but Hispanics had the highest level of objectively measured MVPA. The overestimation by self-report was largest in Whites (251.7 MET-minutes / wk), (P<.01). Figure 2 shows pairwise comparisons of the proportions of each racial/ethnic group meeting the recommended threshold of 150 minutes per week of MVPA, based on objectively measured data. There was no significant difference between Whites and African Americans (P=.755). However, Hispanics met the threshold significantly more than both Whites and African Americans (P<.01 for both comparisons).

Table 3 shows the multivariate adjusted associations of race/ethnicity and achievement of the recommended MVPA goal, based on self-report and objective measures. Using stepwise-adjusted modified Poisson Regression models, African Americans had significantly lower likelihood of self-reporting meeting the MVPA goal compared with Whites, independent of all covariates. Hispanics, on the other hand, had higher likelihood of objectively meeting the MVPA goal from the unadjusted model (PR=1.35

Table 2. Proportion of participants meeting the MVPA goal (500 METs/week)

Cohort characteristics	Self-report		Accelerometer	
	Met MVPA goal, n (weighted %)	P	Met MVPA goal, n (weighted %)	P
Race/ethnicity				
White	130 (67.1)		138 (44.2)	
AA	49 (39.2)	<.0001	88 (42.6)	.0003
Hispanic	52 (55.1)		126 (65.1)	
Sex				
Male	137 (67.4)	.0414	233 (58.8)	<.0001
Female	94 (55.3)		119 (34.7)	
Age				
<65	125 (62.4)	.6527	263 (62.6)	<.0001
≥65	106 (59.6)		89 (21.9)	
Income				
≤200% FPL	83 (54.0)	.0257	139 (36.2)	.0002
>200% FPL	134 (65.7)		193 (53.8)	
Education completed				
< High school	62 (52.9)	.0888	116 (35.1)	.0014
≥ High school	168 (63.6)		235 (50.7)	
BMI				
<25	38 (61.5)		59 (43.3)	
25-30	83 (67.4)	.0916	126 (46.2)	.0771
≥30 kg/m^2	106 (56.5)		164 (43.4)	
Any additional chronic disease?				
Yes	144 (59.8	.4806	163 (34.4)	<.0001
No	87 (63.7)		189 (68.2)	
Vegetarian diet?				
Yes	11 (71.6)	.3541	18 (56.8)	.3897
No	189 (57.9)		301 (46.6)	
DM medication?				
Yes	108 (53.5)	.0016	169 (42.0)	.2868
No	72 (68.9)		98 (48.4)	

[CI: 1.05-1.73]). However, upon further adjustment for independence from all covariates in Models 2 and 3, the significance of this association disappeared (PR = 1.24 [CI: .91-1.69]).

Finally, to identify racial/ethnic differences in the magnitude of the discrepancy between self-reported and objectively measured MVPA, in the unadjusted regression, the discrepancy was much greater in Hispanics than Whites (P=.005). However, this difference between racial/ethnic groups disappeared in the multivariable regression after controlling for age, BMI, education, income, sex, and chronic diseases. (Table 4).

Discussion

We found that in this nationally representative study of type 2 diabetes mellitus patients, a considerable proportion do not meet recommended physical activity levels. African Americans with type 2 diabetes mellitus had the lowest proportion of individuals meeting both the self-reported and objectively measured levels of recommended physical activity. Multiple Diabetes Prevention Program (DPP) lifestyle intervention adaptations, including the Group Lifestyle Balance (GLB) program, have been effective in lowering diabetes risk factors; however, evidence of implementation of such programs in Afri-

Table 3. Modified Poisson regression models for achieving the MVPA goal, across race/ethnicity groups

Outcome: met MVPA goal		Self-report		Accelerometer	
		Prevalence ratio (95% CI)	P	Prevalence ratio (95% CI)	P
Model 1: unadjusted	White	Reference			
	AA	.64 (.42-.98)	.0379	.93 (.64-1.34)	.6875
	Hispanic	.76 (.51-1.13)	.1788	1.35 (1.05-1.73)	.0172
Model 2: adjusted for age, BMI, education, income, sex	White	Reference			
	AA	.63 (.41-0.98)	.0382	.83 (.59-1.17)	.2842
	Hispanic	.77 (.50-1.17)	.2209	1.26 (.92-1.72)	.1483
Model 3: adjusted for age, BMI, education, income, sex + any chronic disease	White	Reference			
	AA	.64 (.42-0.99)	.0430	.83 (.58-1.19)	.3104
	Hispanic	.73 (.48-1.11)	.1431	1.24 (.91-1.69)	.1817

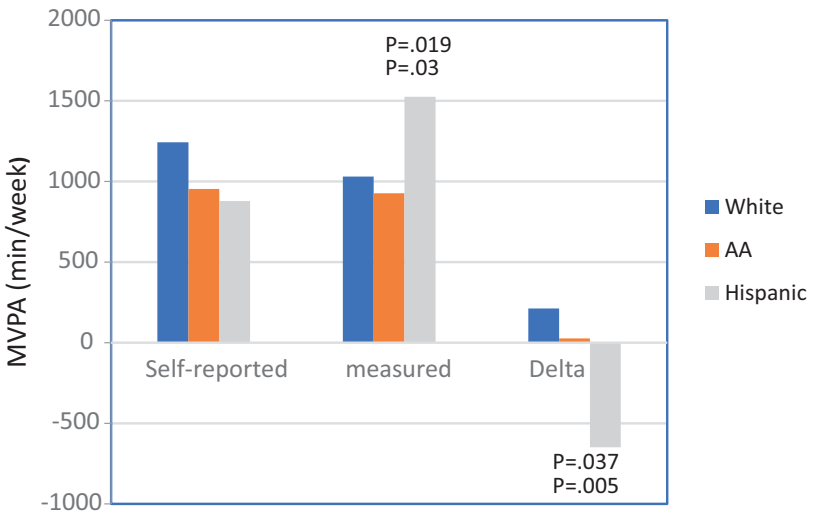

Figure 1. Levels of self-reported and objectively measured MVPA across the racial/ethnic groups in US adults diagnosed with type 2 diabetes mellitus.

can American populations is sparse.

We also found that White patients with type 2 diabetes mellitus significantly overestimated their level of physical activity by way of reporting frequency of MET minutes/week, while their Hispanic counterparts significantly underestimated it when CPM by accelerometer measures were used. Our findings also reveal that the gap between the two measures of MVPA was largest in Hispanics. This might point to interracial differences in the way that daily physical activity is perceived, or the way different racial/ethnic groups regard the role that physical activity plays (or should be expected to play) in everyday life. Such differences in attitudes toward physical activity should also be further explored.

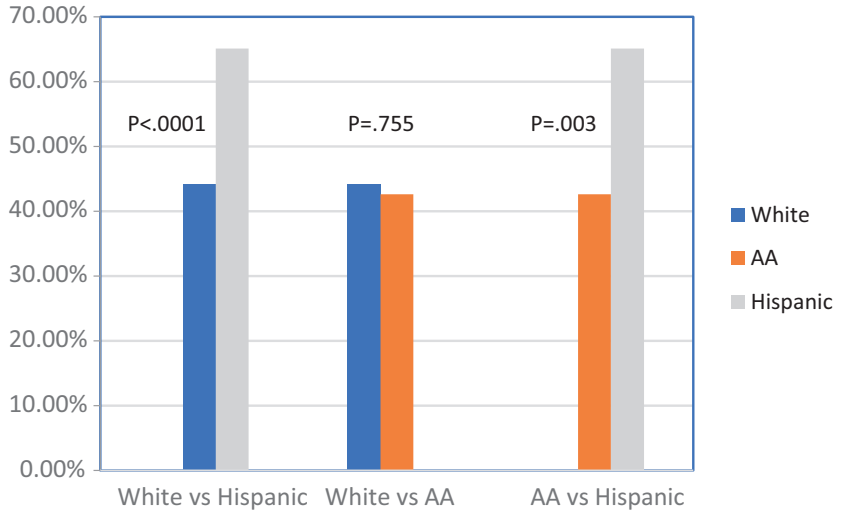

Figure 2. Comparisons of the proportions in each racial/ethnic group meeting the MVPA goal by objective data of US adults diagnosed with type 2 diabetes mellitus.

Our data show that there were no significant differences between Whites and African Americans in meeting the recommended thresholds based on objectively measured data, even though by subjective self-report, African Americans were less likely to achieve the recommended level of MVPA. The reasons that underlie this discrepancy remain unclear, but at least in our analyses, they appear to be unrelated to differences in demographic factors or the burden of chronic diseases. Conversely, we found that significantly more Hispanics achieved the recommended threshold compared with both Whites and African Americans by objective measurement (but also not by subjective report), but this difference disappears after controlling for demographic variables and the burden of chronic diseases.

The greater MVPA level of Hispanic participants is consistent with the previous NHANES 2003-04 data of Toriano et al, who found that Mexican Americans had higher levels of total weekly MVPA compared with Whites and African Americans, although the difference they saw was negated if the data were modified to only count bouts of physical activity >30 minutes.[19] The study by Tucker et al using NHANES 2005-06 data also showed that Mexican Americans had the lowest self-reported physical activity but highest measured physical activity when compared with Whites and African Americans,[21] which is also consistent with our findings. Our observation that Hispanics are more likely to achieve the

Table 4. Multivariate regression models for discrepancy between self-reported physical activity and accelerometer measured physical activity across race/ethnicity groups

Outcome: Discrepancy		β (SE)	P
Model 1: Unadjusted	White	Reference	
	AA	-185.5 (192.6)	.3432
	Hispanic	-860.2 (289.4)	.005
Model 2: Adjusted for age, BMI, education, income, sex	White	Reference	
	AA	29.2 (190.9)	.8794
	Hispanic	-618.9 (342.2)	.0806
Model 3: Adjusted for age, BMI, education, income, sex + any chronic diseases	White	Reference	
	AA	26.8 (191.8)	.8898
	Hispanic	-634.4 (335.3)	.0682

recommended weekly physical activity goal suggests that physical activity level is not the sole factor influencing their overall burden of metabolic disease. Further studies will clearly be needed to control for multiple other confounding factors such as diet/nutrition and/or medication usage.

Additionally, while initially our findings show that discrepancy between self-reported and objective measured physical activity is greater in Hispanics than Whites and African Americans, such discrepancy disappeared in the multivariable regression after controlling for age, BMI, education, income, sex, and any chronic disease.

Limitations

Our findings may be subject to some limitations. The self-report survey did not account for occupation-related physical activity, which may have confounded the accuracy of self-report differentially for racial/ethnic groups that may differ according to traditional "blue-collar" or "white-collar" occupations. The accelerometer used in NHANES was a unidirectional accelerometer and because it was not waterproof, we could not account for aquatic activities such as swimming. Nevertheless, this limitation was the same for all participants, so comparisons across participants should still be valid. Body placement of the accelerometer at the waist also may have underestimated activity that was restricted to upper body movement or movements with extra effort such as walking uphill or carrying loads.[21] Also, the 2,020 CPM threshold for defining moderate physical activity was developed using treadmill and walking data from four studies that included mostly young adults,[26] and thus, it may not have accurately accounted for the decline in exercise tolerance in older adults.[19] Moreover, our results from participants with diabetes limits its generalizability to the general population.

We found that in this nationally representative study of type 2 diabetes mellitus patients, a considerable proportion do not meet recommended physical activity levels.

Conclusion

Our findings show that a considerable proportion of type 2 diabetes mellitus patients do not meet recommended physical activity levels. African Americans with type 2 diabetes had the lowest proportion of meeting both self-reported and objectively measured levels of recommended physical activity. Our study also highlights discrepancies between self-reported and objectively measured physical activity. Our findings showed that, compared with Hispanics and African American participants, Whites had the greatest discrepancy in self-reporting levels of physical activity. That is, White patients with diabetes overestimated their level of physical activity (self-reported frequency of MET minutes/week), while their Hispanic counterparts significantly underestimated it when CPM by accelerometer measures were used. Also, the gap between the two measures of MVPA was greatest among Hispanics. A better understanding of racial/ethnic differences in physical activity among patients with diabetes will enable physicians to better tailor treatment strategies for their patients. More routine use of objectively measured physical activity tools should also be encouraged to more accurately understand these factors. Objective mea-

surement of physical activity is now easily available through cell phones and wristband devices, and they can be used to improve an understanding of the roles of physical activity.

Acknowledgments

This research was funded by: Accelerating Excellence in Translational Science Center (AXIS NIH-NIMHD U54MD007598); UCLA Clinical and Translational Science Institute (NIH/NCATS Grant # UL1TR000124);Life Sciences Institute (NIH-NIMHD Grant# S21MD000103)

Conflict of Interest

No conflicts of interest to report.

Author Contributions

Research concept and design: Bazargan-Hejazi, Arroyo, Hsia, Rouhi Brojeni; Acquisition of data: Bazargan-Hejazi, Pan; Data analysis and interpretation: Bazargan-Hejazi, Arroyo, Hsia, Pan; Manuscript draft: Bazargan-Hejazi, Arroyo, Hsia, Rouhi Brojeni, Pan; Statistical expertise: Rouhi Brojeni, Pan; Administrative: Arroyo; Supervision: Bazargan-Hejazi, Hsia.

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