RESEARCH ARTICLE

Differences in association of leisure time activities and cognition in a racially/ethnically diverse cohort of older adults: Findings from the KHANDLE study

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Abstract

Introduction: Leisure time activity is associated with better cognitive function but has not been well studied in racially/ethnically diverse cohorts, who may have different access to activities.

Methods: Frequency of participation in 10 leisure time activities (eg, reading, attending cultural events) and cognition (executive function, semantic memory, and verbal episodic memory) were assessed at Wave 1 in the Kaiser Healthy Aging and Diverse Life Experiences (KHANDLE) study, a prospective cohort initiated in 2017. Linear regression models adjusted for sociodemographics and depression estimated cross-sectional associations between leisure time activity variety and frequency and cognitive domains overall and by race/ethnicity. Logistic regression models estimated odds of cognitive impairment among those in the lowest quartiles of activity variety and frequency. All models controlled for age, sex, education, income, retirement status, and depression.

Results: Higher leisure time activity variety was significantly associated with better cognition for all, except for verbal episodic memory among Asians ($\beta = 0.05$, 95% confidence interval [CI]: −0.004, 0.11) and semantic memory among Latinos ($\beta = 0.04$, 95% CI: −0.01, 0.08). Low activity variety was associated with nearly three-fold increased odds of cognitive impairment (adjusted odds ratio [OR] = 2.87, 95% CI: 1.77, 4.64). Activity frequency was associated with higher executive function only among whites ($\beta = 0.10$, 95% CI: 0.02, 0.18). Patterns by race/ethnicity were not explained by education.

Discussion: Engaging in a wider variety of leisure time activities may be more important than frequently participating in fewer activities for cognitive aging in racially/ethnically diverse cohorts.

KEYWORDS
cognitive aging, leisure time activity, race/ethnicity

1 | INTRODUCTION

Cognitively stimulating leisure time activities have been positively associated with healthy cognitive aging in a large and growing body of research.[1,2,3–10,11–13] Many observational studies have found that participating in activities such as reading, writing, playing games, and attending cultural events (eg, museums, performance arts) at various points in the lifecourse is associated with better cognitive functioning,[2,4,6,7,12] slower cognitive decline,[5,6,8,9,13,14] and a lower risk of cognitive impairment.[3,9,11] Intervention studies have also found short-term improvements in cognition with some types of activities, such as playing an instrument;[15] learning digital photography;[16] and using virtual reality to engage in instrumental activities of daily living, such as navigating a city and shopping.[17]

While these studies are promising, the impact of leisure activities on cognition in diverse populations is not well understood. We have identified only one study that has examined engagement in leisure time cognitive activities and cognitive function in a multi-racial/ethnic cohort.[6] The study found higher participation in leisure time cognitive activities was associated with higher baseline cognition and a slower rate of cognitive decline for both black and white participants, though the effect was stronger for whites.[6] To our knowledge, no other studies have harmonized data on multiple racial/ethnic groups or tested effect modification by group in the relationship between leisure time cognitive activities and cognitive aging. Previous research has found blacks and Latinos have an increased risk of dementia compared to whites while Asians have the lowest risk.[18] Delineation of the role of leisure activities on cognition in diverse populations is critical because evidence suggests cognitive engagement is protective in primarily white cohorts, but the relationship is not well characterized in some race/ethnic groups at higher risk of dementia.[18]

This study aims to address this gap in a diverse cohort of older adults of multiple different racial/ethnic groups. We examined associations between the variety and frequency of participation in leisure time activities and overall and domain-specific cognition. We also examined if race/ethnicity modifies the effect of these associations. By investigating race/ethnic patterns in the association between cognition and leisure time activities we hope to shed light on the opportunities and limitations of leisure time activities to promote healthy cognitive aging and reduce cognitive aging disparities in an increasingly diverse population of older adults.

2 | METHODS

2.1 | Sample

We used Wave 1 data from the Kaiser Healthy Aging and Diverse Life Experiences (KHANDLE) study, a prospective cohort comprised of community-dwelling older adults residing in the San Francisco Bay area and Sacramento valley. KHANDLE aims to evaluate how life course and sociocultural factors influence late-life brain health and cognitive decline and may contribute to racial/ethnic disparities. Individuals eligible for KHANDLE were long-term members of Kaiser Permanente Northern California (KPNC) who were age 65 or older on January 1, 2017, spoke English or Spanish, and who previously participated in one or more Kaiser Permanente Multiphasic Health Checkups (MHC) between 1964 and 1985. Stratified random sampling by race/ethnicity and educational attainment was used with the goal of recruiting approximately equal proportions of Asian, black, Latino, and white participants and diversity in educational attainment. Exclusion criteria included: electronic medical record diagnosis of dementia or other neurodegenerative disease (frontotemporal dementia, Lewy body disease, Pick's disease, Parkinson's disease with dementia, Huntington's disease); and presence of health conditions that would impede participation in study interviews, defined by hospice activity in the past 12 months, history of severe chronic obstructive pulmonary disease in the past 6 months, congestive heart failure hospitalizations in the past 6 months, and history of end stage renal disease or dialysis in the past 12 months. Participants were interviewed in their homes or at KPNC clinics from March 2017 to December 2018, totaling 1712 enrolled participants. The study was approved by the KPNC and University of California (UC) Davis Institutional Review Boards and all enrolled participants provided informed consent.

2.2 | Measures

2.2.1 | Race/ethnicity

Race/ethnicity was self-reported at participant interview, or obtained from the participant's medical record when missing, and classified as non-Latino white, non-Latino black, non-Latino Asian, or Latino.

2.2.2 | Cognition

Three cognitive domains (verbal episodic memory, semantic memory, and executive functioning) were assessed by the Spanish and English Neuropsychological Assessment Scales (SENAS) at Wave 1. The SENAS was administered during baseline interviews in either English or Spanish, with language of administration determined by an algorithm that considered preferred language and everyday language usage in a variety of settings. The SENAS is a battery of cognitive tests that has previously undergone extensive development for valid comparisons of cognitive change across racial/ethnic and linguistically diverse groups.[19,20] A verbal episodic memory score was derived from a multi-trial word-list-learning test. Semantic memory was measured using a composite score that was derived from verbal (object-naming) and nonverbal (picture association) tests. An executive function composite score was obtained using component tasks of category fluency, phonemic (letter) fluency, and working memory (digit-span backward, visual-span backward, list sorting). Details of the administration procedures, development, and psychometric characteristics have been extensively described in previous publications.[19,20] Overall cognition was defined as the mean of verbal episodic memory, semantic memory, and executive function scores. Each domain and overall cognition were z-standardized using the baseline sample mean and standard deviation.

2.2.3 | Leisure time activities

During Wave 1 interviews, participants were asked if they participated in 10 leisure time activities: arts or crafts (photography, painting, sewing, woodworking, auto mechanics, etc), taking classes or learning new skills or subjects, going to club meetings or attending religious activities, complex cooking (new recipes, multi-dish meals, etc), going to cultural events (movies, live theater, concerts, museums, etc), games or puzzles (crosswords, cards, checkers, chess, computer games, etc), performance arts (singing, playing an instrument, acting, etc), reading (newspaper, magazines, books, internet, etc), socializing/talking with friends and family, and writing (letters, journal, stories, email, etc). For each leisure time activity, participants rated their frequency of participation on a five-point Likert scale: (4) every day, or almost every day; (3) several times a week; (2) several times a month; (1) several times a year; (0) never.

We assessed participants' leisure time activity variety by creating a summary score (range 0 to 10) where activities that were participated in at least several times per month or more were assigned a value of 1, and all others assigned 0. We also estimated mean frequency of engaging in any weekly leisure time activity by recoding the categorical scale as follows: every day, or almost every day = 7; several times a week = 3; several times a month = .75; several times a year = .05. We then divided the sum of the frequency in all activities (range 0 to 70) by the number of activities in which they ever participate (range 0 to 10).

RESEARCH IN CONTEXT

1. Systematic review: We searched PubMed for observational studies reporting the association between leisure time cognitive activities and cognitive aging, cognitive impairment, or dementia by race/ethnicity. We identified only one study, which compared blacks and white cohort participants but did not have data on other race/ethnic groups.

2. Interpretation: The findings from a diverse cohort of older adults (comprised of Asians, blacks, Latinos, and whites) demonstrate that participating in a greater variety of leisure time activities is associated with better cognitive function across multiple domains of cognition in all race/ethnic groups examined, while the frequency of leisure time activities is only positively associated with executive function among whites.

3. Future directions: Future research should continue to examine race/ethnic differences in the associations between characteristics of leisure time activities (eg, social vs individual) and incident cognitive impairment.

2.2.4 | Covariates

Age and sex were collected during the study interview or, if missing, obtained from the participant's electronic medical record. Age was operationalized as a continuous measure (age 65+). Education, household income, and retirement status were collected from participant interviews. Education was captured through a series of questions related to degree and certification obtainment and recoded as years of education. Household income was reported in 14 categories (< $9999; $10,000 to $14,999; $15,000 to $19,999; $20,000 to $24,999; $25,000 to $34,999; $35,000 to $44,999; $45,000 to $54,999; $55,000 to $64,999; $65,000 to $74,999; $75,000 to $99,999; $100,000 to $124,999; $125,000 to $149,999; ≥$150,000; missing) and converted to a continuous variable using the lowest value for each non-missing category. Individuals who reported being retired and not working full or part time for pay were classified as being retired. Depression was assessed using the standardized National Institutes of Health (NIH) Toolbox Patient-Reported Outcomes Measurement Information System (PROMIS) measure.

2.3 | Analytic sample and missingness

Of the 1712 participants in KHANDLE's Wave I cohort, we excluded 287 because of missingness on key variables. Four were excluded based on reporting race other than Asian, black, Latino, or white; 25 were missing on leisure time activity participation; 21 were missing

the SENAS scores; 203 were missing on income; 34 were missing on retirement status; and 26 were missing a depression score. We ran supplemental imputation models to account for missingness, described below. The remaining 1399 individuals comprised the analytic cohort.

2.4 | Statistical analysis

We compared the means or frequencies of leisure time activity variety and frequency, demographics, and cognitive function by race/ethnicity using analysis of variance (ANOVA) or chi-square tests, as appropriate. We used linear regression to examine cross-sectional associations between leisure time activity variety and frequency and overall cognition, verbal episodic memory, semantic memory, and executive function. Using logistic regression, we assessed the odds of cognitive impairment, defined as having a cognitive test score at or below 1.5 standard deviations of the mean, among those in the lowest quartile of activity variety or frequency compared to all others. We also tested for effect modification by race to further examine how participation in leisure time activities, as a modifiable risk factor, may help to explain race/ethnic disparities in cognitive scores. Effect modification was examined by comparing model fit with and without interaction terms using likelihood ratio tests at $P < .10$. Pooled and race-stratified models are reported for all analyses. When effect modification was present, we reported predicted values of cognition when participants are at the highest and lowest observed values for activity variety and frequency and all other covariates are at the mean. All models controlled for age, sex, education, income, retirement status, and depression.

In supplemental analyses, we examined potential non-linearity by modeling activity variety and frequency as quartiles. We found no evidence of non-linearity and therefore report the findings from the linear models below. In sensitivity analyses, we conducted multiple imputation by chained equations (MICE) models of our primary regression analyses using 10 imputations to account for missingness in SENAS scores (1.2%), leisure time activities (1.5%), depression (1.8%) and demographic covariates (14.1%), of which income had the highest level of missing data (11.9%). Prior to imputation we tested the relationship between missing on income and race, finding none ($X^2 P = .80$). MICE models produced comparable estimates to our primary analyses (results not shown); we therefore report findings from our primary analyses. All programming was completed in Stata 14 (StataCorp, College Station, Texas, USA).

3 | RESULTS

The sample had 1399 participants with complete information and was 24.9% Asian, 25.7% black, 19.6% Latino, and 29.8% white participants (Table 1). Participants had a mean age of 75.6 (standard deviation [SD] = 6.5) years and a mean education of 14.9 (SD = 2.9) years; highest mean education was among Asians (15.7, SD = 2.5), and lowest was among Latinos (13.8, SD = 3.5). About 80% of the sample was retired,

though only 72% of bBlacks were retired. Blacks and whites participated in a comparable variety of activities (blacks: mean = 5.8, SD = 1.9; whites: mean = 5.8, SD = 1.8), while Asians and Latinos reported participating in fewer activities (Asians: mean = 5.5, SD = 1.9; Latinos: mean = 5.4, SD = 2.0). Mean frequency of leisure time activities was 3.2 (SD = 1.2) times per week and did not vary by race/ethnicity.

Activity variety was positively associated with cognitive function in all cognitive domains in the pooled sample. Race-specific associations were significant except for the association with semantic memory for Latinos ($\beta = 0.04$, 95% confidence interval [CI]: −0.01, 0.08), and verbal memory for Asians ($\beta = 0.05$, 95% CI: −0.004, 0.11; Table 2). Overall, we observed a per-activity mean increase in cognitive test score of 0.10 (95% CI: 0.08, 0.12) standard deviations for overall cognition, 0.09 (95% CI: 0.06, 0.11) for executive function, 0.07 (95% CI: 0.05, 0.09) for semantic memory, and 0.08 (95% CI: 0.06, 0.11) for verbal memory.

Activity frequency in the pooled sample was not associated with any cognitive domain: overall cognition ($\beta = 0.01$, 95% CI: −0.02, 0.05), executive function ($\beta = 0.03$, 95% CI: −0.09, 0.15), semantic memory ($\beta = 0.01$, 95% CI: −0.03, 0.04), or verbal memory (−0.01, 95% CI: −0.04, 0.03; Table 3). In race-stratified models, activity frequency was positively associated with executive function among whites ($\beta = 0.10$, 95% CI: 0.02, 0.18), but there was no significant association between activity frequency and overall cognition, semantic memory, or verbal memory within any race/ethnic group.

In logistic regression models, those in the lowest quartile of activity variety had substantially higher odds of impaired cognition across all domains: impaired overall cognition odds ratio (OR) 2.87 (95% CI: 1.77, 4.64); impaired executive function OR 1.91 (95% CI: 1.17, 3.13); impaired semantic memory OR 1.94 (95% CI: 1.24, 3.02); and impaired verbal memory OR 2.13 (95% CI: 1.34, 3.38; Table 4, Column A). The odds of cognitive impairment among those with the lowest activity variety were further increased for all cognitive domains when we accounted for activity frequency in our analyses (Table 4, Column B). By contrast, the lowest quartile of activity frequency was only associated with increased odds of impaired semantic memory (OR: 1.61; 95% CI: 1.03, 2.52; Table 4, Column C).

In interaction models, we found that race/ethnicity modified the association of activity variety with executive function (P-value = .07). Figure S1 in supporting information shows the adjusted predicted values of executive function for each race/ethnic group at levels of leisure time activity variety. The predicted values demonstrate a steeper slope for whites such that the difference in executive function between whites and other race groups widens as activity variety increases. For example, the difference in mean standardized levels of executive function between participating in 0 and 10 different activities is 1.33 standard deviations for whites, while for Asians, blacks, and Latinos, these differences are 0.90, 0.96, and 0.66, respectively (Table 5). We also found that race/ethnicity significantly modified the associations of activity frequency with overall cognition (P-value = 0.04), executive function (P-value = 0.02), and semantic memory (P-value = 0.03). Figures S2, S3, and S4 in supporting information show the adjusted predicted values of overall cognition, executive function, and semantic

TABLE 1 Characteristics of the analytic sample from KHANDLE Wave I, overall and by race/ethnicity

Population characteristic	Mean (SD) or %					
	Overall (n = 1399)	Asian (n = 348)	Black (n = 360)	Latino (n = 274)	White (n = 417)	P-value[a]
Age (y)	75.6 (6.5)	75.3 (6.3)	74.7 (6.2)	75.9 (6.3)	76.3 (6.9)	0.008
Females (%)	58.5	52.9	67.5	54.7	58.0	<0.001
Education (y)	14.9 (2.9)	15.7 (2.5)	14.5 (2.5)	13.8 (3.5)	15.3 (2.8)	<0.001
Current Income ($1000s)	73.1 (40.9)	85.1 (41.7)	66.8 (40.03)	62.0 (37.1)	75.7 (40.2)	<0.001
Retired and not working (%)	79.3	82.5	72.2	82.1	81.1	0.002
Depression[b]	−0.10 (0.72)	−0.16 (0.77)	−0.14 (0.72)	−0.04 (0.74)	−0.05 (0.64)	0.070
Overall cognition[c]	0.07 (0.97)	−0.11 (0.88)	−0.27 (0.85)	−0.08 (0.87)	0.60 (0.98)	<0.001
Executive function	0.06 (0.98)	−0.15 (0.83)	−0.18 (0.85)	−0.18 (0.86)	0.59 (1.07)	<0.001
Semantic memory	0.07 (0.98)	−0.26 (0.99)	−0.42 (0.83)	0.15 (0.86)	0.70 (0.77)	<0.001
Verbal memory	0.04 (0.98)	0.13 (0.98)	−0.05 (0.88)	−0.15 (0.95)	0.17 (1.05)	<0.001
Arts and crafts[d]	35.5	35.3	30.8	32.5	41.5	0.011
Attend classes[d]	28.9	28.7	29.2	23.4	32.4	0.087
Cultural events[d]	39.8	30.8	42.2	44.5	42.2	0.001
Clubs/religious groups[d]	55.5	44.8	69.4	55.5	52.3	<0.001
Complex cooking[d]	54.3	53.2	58.9	54.4	51.1	0.173
Games[d]	60.6	58.6	62.5	55.1	64.3	0.074
Performance arts[d]	19.3	20.4	19.7	17.5	19.2	0.832
Reading[d]	97.4	98.3	96.4	95.3	99.0	0.007
Socializing[d]	96.6	95.1	96.7	95.3	98.6	0.034
Writing[d]	77.2	80.5	75.8	67.5	82.0	<0.001
Mean frequency of activities/week (0 to 7)	3.2 (1.2)	3.2 (1.2)	3.2 (1.2)	3.2 (1.3)	3.2 (1.1)	0.905
Variety of activities (0 to 10)	5.7 (1.9)	5.5 (1.9)	5.8 (1.9)	5.4 (2.0)	5.8 (1.8)	0.003

Abbreviation: KHANDLE, Kaiser Healthy Aging and Diverse Life Experiences study.

[a]Test of the null hypothesis (analysis of variance or X[2]) that the mean of each variable is the same for all four racial/ethnic groups.

[b]Depression was assessed with the National Institutes of Health (NIH) Toolbox Patient-Reported Outcomes Measurement Information System (PROMIS) measure and standardized to a reference population that is generalizable to the 2000 U.S. Census.

[c]Overall cognition is the standardized mean of executive function, semantic memory, and verbal memory. All cognitive domains have been standardized to the KHANDLE Wave I cohort.

[d]Percent who reported engaging in the activity at least several times per month.

TABLE 2 Linear regression models for the association between variety of cognitive activity participation and z-standardized cognitive test scores for the full sample and stratified by race, KHANDLE

Cognitive domain	Overall	Asian	Black	Latino	White
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
Overall cognition	0.10 (0.08,0.12)	0.10 (0.05, 0.14)	0.11 (0.07, 0.15)	0.07 (0.03, 0.11)	0.11 (0.07, 0.16)
Executive function	0.09 (0.06, 0.11)	0.08 (0.04, 0.13)	0.09 (0.05, 0.13)	0.06 (0.02, 0.11)	0.11 (0.06, 0.16)
Semantic memory	0.07 (0.05, 0.09)	0.10 (0.04, 0.16)	0.06 (0.02, 0.10)	0.04 (−0.01, 0.08)	0.08 (0.04, 0.11)
Verbal memory	0.08 (0.06, 0.11)	0.05 (−0.004, 0.11)	0.12 (0.07, 0.17)	0.07 (0.02, 0.13)	0.09 (0.04, 0.14)

Note: All models adjust for age, sex, education, income, retirement status, and depression.

Abbreviation: KHANDLE, Kaiser Healthy Aging and Diverse Life Experiences study.

memory at levels of mean activity frequency for each race/ethnic group. For overall cognition, there is a positive trend for Asians and whites, with increased activity frequency associated with a 0.40 and a 0.43 standard deviation increase in cognition, respectively (Figure S2, Table 5). By contrast, the predicted values for Blacks and Latinos showed decreasing overall cognition with increased frequency by 0.39 and 0.05 standard deviations, respectively. The predicted values of executive function demonstrate a steeper slope

TABLE 3 Linear regression models for the association between frequency of cognitive activity participation and z-standardized cognitive test scores for the full sample and stratified by race/ethnicity, KHANDLE

Cognitive domain	Overall β (95% CI)	Asian β (95% CI)	Black β (95% CI)	Latino β (95% CI)	White β (95% CI)
Overall cognition	0.01 (−0.02, 0.05)	0.05 (−0.02, 0.12)	−0.05 (−0.12, 0.01)	−0.01 (−0.07, 0.06)	0.06 (−0.01, 0.13)
Executive function	0.03 (−0.09, 0.15)	0.06 (−0.004, 0.13)	−0.5 (−0.12, 0.02)	0.01 (−0.06, 0.08)	0.10 (0.02, 0.18)
Semantic memory	0.01 (−0.03, 0.04)	0.07 (−0.02, 0.16)	−0.05 (−0.12, 0.01)	−0.01 (−0.08, 0.05)	0.02 (−0.02, 0.18)
Verbal memory	−0.01 (−0.04, 0.03)	0.01 (−0.09, 0.07)	−0.03 (−0.10, 0.05)	−0.02 (−0.10, 0.06)	0.03 (−0.05, 0.11)

Note: All models adjust for age, sex, education, income, retirement status, and depression.
Abbreviation: KHANDLE, Kaiser Healthy Aging and Diverse Life Experiences study.

TABLE 4 Odds of impaired cognition (falling at or below 1.5 standard deviations below the mean) among those in the lowest quartile of activity variety (Models A and B) and frequency (Model C), compared to those not in the lowest quartile of activity variety or frequency (ref.)

Cognitive domain	A. Activity variety OR (95% CI)	B. Activity variety, adjusted for activity frequency OR (95% CI)	C. Activity frequency OR (95% CI)
Impaired overall cognition	2.87 (1.77, 4.64)	3.01 (1.85, 4.89)	1.40 (0.85, 12.29)
Impaired executive function	1.91 (1.17, 3.13)	2.02 (1.23, 3.31)	1.19 (0.71, 2.00)
Impaired semantic memory	1.94 (1.24, 3.02)	1.91 (1.22, 2.98)	1.61 (1.03, 2.52)
Impaired verbal memory	2.13 (1.34, 3.38)	2.27 (1.42, 3.63)	1.08 (0.66, 1.77)

Note: All models adjusted for age, sex, race, income, education retirement status, and depression.
Abbreviations: CI, confidence interval; OR, odds ratio

TABLE 5 Adjusted predicted values of cognition when mean frequency of activity engagement is never (0) and almost daily (4), or variety of activity engagement is at none (0) or all (10), by race and cognitive domain from models of effect modification by race/ethnicity

	Asian	Black	Latino	White
Global cognition				
Variety = 0	−0.69 (−0.93, −0.45)	−0.85 (−1.09, −0.61)	−0.29 (−0.54, −0.04)	−0.18 (−0.42, 0.06)
Variety = 10	0.21 (0.01, 0.42)	0.11 (−0.07, 0.58)	0.37 (0.15, 0.58)	1.15 (0.97, 1.33)
Mean frequency = 0	−0.39 (−0.62, −0.16)	−0.12 (−0.34, 0.10)	0.11 (−0.13, 0.35)	0.40 (0.17, 0.62)
Mean frequency = 7	0.01 (−0.25, 0.27)	−0.51 (−0.77, −0.25)	0.06 (−0.22, 0.34)	0.83 (0.56, 1.09)
Executive function				
Variety = 0	−0.63 (−0.89, −0.38)	−0.68 (−0.94, −0.43)	−0.32 (−0.59, −0.05)	−0.18 (−0.43, 0.08)
Variety = 10	0.10 (−0.12, 0.32)	0.14 (−0.05, 0.34)	0.20 (−0.03, 0.43)	1.13 (0.94, 1.32)
Mean frequency = 0	−0.46 (−0.70, −0.22)	−0.05 (−0.28, 0.18)	−0.06 (−0.31, 0.20)	0.26 (0.02, 0.50)
Mean frequency = 7	0.03 (−0.25, 0.31)	−0.41 (−0.68, −0.13)	0.03 (−0.27, 0.32)	0.96 (0.68, 1.25)
Semantic memory				
Variety = 0	−0.88 (−1.13, −0.64)	−0.74 (−0.99, −0.49)	0.03 (−0.23, 0.29)	0.22 (−0.02, 0.47)
Variety = 10	0.07 (−0.14, 0.29)	−0.12 (−0.31, 0.07)	0.43 (0.21, 0.65)	1.03 (0.85, 1.21)
Mean frequency = 0	−0.63 (−0.86, −0.40)	−0.21 (−0.44, 0.01)	0.34 (0.10, 0.58)	0.63 (0.40, 0.87)
Mean frequency = 7	−0.06 (−0.33, 0.21)	−0.60 (−0.86, −0.33)	0.18 (−0.11, 0.46)	0.76 (0.49, 1.03)
Verbal episodic memory				
Variety = 0	−0.17 (−0.45, 0.10)	−0.65 (−0.93, −0.37)	−0.42 (−0.72, −0.13)	−0.48 (−0.76, −0.21)
Variety = 10	0.35 (0.11, 0.58)	0.26 (0.05, 0.47)	0.27 (0.02, 0.52)	0.67 (0.46, 0.87)
Mean frequency = 0	0.14 (−0.12, 0.40)	−0.03 (−0.28, 0.23)	−0.01 (−0.29, 0.26)	0.08 (−0.18, 0.34)
Mean frequency = 7	0.06 (−0.24, 0.36)	−0.25 (−0.55, 0.05)	−0.05 (−0.37, 0.27)	0.31 (0.00, 0.62)

Note: Values calculated setting all other covariates at the mean. Models adjusted for age, sex, income, education, retirement status, and depression.

for whites such that the difference in cognition between whites and other race groups widens as leisure time activity frequency increases, a pattern similar to that observed for activity variety (Table S3 in supporting information). By contrast, the modified effect of mean activity frequency with semantic memory shows a strong positive association with semantic memory for Asians (Figure S4), albeit only the predicted values for whites are statistically significant (Table 5).

We explored whether the observed relationships were motivated by higher educational attainment by examining activity variety and frequency stratified by education (less than high school, high school or general education diploma [GED], and greater than high school), controlling for age, sex, race/ethnicity, income, retirement status, and depression. The findings from these analyses suggest that there is a pattern by education in the association of leisure time activities with cognition, such that the magnitude of association between activity variety and cognition is highest among those with less than high school (overall cognition $\beta = 0.12$, 95% CI: 0.01, 0.23) compared to those who had completed high school or earned a GED (overall cognition $\beta = 0.07$, 95% CI: 0.00, 0.13) or had education beyond high school (overall cognition $\beta = 0.11$, 95% CI: 0.09, 0.13; Table S1 in supporting information). Had our findings been driven by education, we would have expected the highest education group—in which whites have the largest representation (30%)—to have the strongest magnitude of association. By contrast, our education-stratified analyses show that the strongest association was among the lowest education group—among whom Latinos comprise the majority (37%). This suggests patterns of differential educational attainment among race/ethnic groups are not driving the race/ethnic-specific findings in our primary analyses.

4 | DISCUSSION

Our study found that participating in greater leisure time activity variety was associated with better cognition for all race groups. However, the effect of activity variety on executive function was stronger among whites. Activity frequency was only associated with better executive functioning among whites. Race/ethnicity-specific associations between activity participation and cognitive test scores were not explained by differences in educational attainment.

Our findings are in alignment with prior research examining the association of leisure time activities with various cognitive domains. Specifically, past studies have shown positive associations between leisure time activities and semantic memory,[2,5,12] executive function,[5] processing speed,[16] perceptual speed,[2] and visuospatial ability,[12] though there has been a discrepancy in findings for episodic memory.[2,9,12,16] Our study extends these findings to show that the association between leisure time activities and executive function and semantic memory varies by race/ethnicity, highlighting the importance of examining both group- and domain-specific patterns in risk and protective factors for cognitive aging.

Our finding that greater activity variety was associated with cognition for all race/ethnic groups, while activity frequency was not, suggests the importance of engaging in diverse forms of cognitive stimulation for cognitive aging. These results are similar to prior research from the Women's Health and Aging Study cohort, which found that participation in a greater activity variety with varying levels of cognitive complexity was a better predictor of cognitive impairment than increased activity frequency.[9] One explanation for these observations is that some leisure time activities may be beneficial for cognition while others are not, and engaging in a greater variety of activities increases the likelihood of participating in one or more that are beneficial. Alternatively, participation in a greater variety of activities may also increase the likelihood of challenging one's cognition with novel activities. This latter hypothesis reflects one of the key takeaways from an intervention study that randomized participants to active learning tasks that developed new knowledge and skills versus structured activities using existing knowledge and skills.[16]

Novel rather than routine forms of cognitive stimulation may be more effective at building cognitive reserve, the dynamic capacity of the brain to recruit alternative neural networks to preserve function in the face of pathological changes.[21,22] The cognitive reserve hypothesis stems from neuroimaging and autopsy research that has found that neuropathology in individuals who have higher levels of education, literacy, IQ, or other proxies of cognitive stimulation is associated with fewer clinical symptoms of cognitive impairment compared to those who have similar levels of pathology but lower levels of cognitive stimulation proxies.[21,23] Although the majority of cognitive reserve research has not used direct measures of cognitive stimulation, mouse models suggest that enriching environments that have increased cognitive novelty and challenge can increase brain-derived neurotrophic factor and help to spur new synapses and dendritic branching in the neural network.[24] Additionally, observational studies of humans with available neuropathology markers have found that leisure time activities are associated with better cognitive functioning, even in the presence of neuropathology.[3,7,11]

The cross-sectional design and potential for unmeasured confounding are the key limitations in our study. We cannot eliminate the potential issue of reverse causation—that those with better cognition are more likely or able to engage in a variety of cognitive activities on a more frequent basis. Additionally, limitations on statistical power prevented us from simultaneously exploring race/ethnic and sex differences; this intersectionality may be critical to fully understanding the observed patterns. However, when we examined models stratified for sex controlling for race/ethnicity, we observed a similar pattern to our overall findings where activity variety betas were of approximately equal magnitude for both males and females, and significant for all cognitive domains. Activity frequency was non-significant in all associations except among males for overall cognition and executive function (results not shown.) We are also limited by self-report of activity measures, which could be influenced by social desirability bias or memory, and the unknown generalizability of the KHANDLE sample beyond northern California. However, our study had several

strengths. The KHANDLE cohort is race/ethnically and educationally diverse. The study's detailed measures allowed us to examine both frequency and type of leisure time activities, as well as include careful measurement of education and income. The SENAS is sensitive to variation in cognitive function even at the higher end of cognitive abilities, allowing for better detection of relationships between various health and lifestyle factors and cognition among those who are cognitively healthy.

Our study fills an important gap in the literature by examining race/ethnic differences in the association between leisure time activities and cognition at older ages. Our analyses additionally show the relationships between leisure time activities and cognition are not driven by educational attainment, pointing to the importance of examining possible mechanisms for these associations at mid- and late-life, including cognitive stimulation, social engagement, and stress reduction. Our study generates several hypotheses to be examined. Future epidemiology studies should more closely examine how the varying dimensions of the activities (eg, social vs solitary) may further explain the relationship between leisure time activities and cognitive aging for diverse groups of older adults. Future intervention studies should consider the importance of simultaneously testing and comparing a variety of cognitively engaging activities rather than limiting focus to a single activity. Additionally, prior research has found that leisure time activity participation in late-life was associated with reduced risk of mild cognitive impairment and dementia.[25,26] That we observed an overarching pattern where leisure time activity variety is more relevant than frequency for all race/ethnic groups provides insights for how increasing activity variety may be tested as a means to reduce race/ethnic disparities in cognitive impairment and dementia.

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CONFLICTS OF INTEREST

The authors have no financial interests in the subject matter or findings presented in this study.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.