USING GPS DATA TO EXPLORE DEMOGRAPHIC PREDICTORS OF LIFE-SPACE: A POOLED ANALYSIS

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ABSTRACT

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Abstract: Life-space is defined as an individual's spatial movement through the environment as covered in daily living. A restricted life-space is associated with cognitive decline, Alzheimer's disease, frailty and depression. We sought to use GPS data to explore demographic predictors of a restricted life-space.

Methods: An exploratory, cross-sectional analysis was conducted using GPS data from seven studies (n=669) provided by the Research in Environment, Active Aging & Community Health (REACH) center at University of California, San Diego. GPS data was converted into minutes spent in each life-space (within the home, within the immediate neighborhood, outside the neighborhood). Demographic variables (age, education, marital status, race, income, BMI, and employment) were standardized across studies. Associations between time spent in each life-space and demographics were analyzed within each study and in a pooled sample. Bivariate analyses and multivariable analyses using GEE models were conducted.

Results: Employment was the strongest and most consistent predictor of time spent within each life-space ($p<0.001$). Participants who were employed full-time spent the most amount of time outside the neighborhood. Older age ($p=018$), being presently married ($p=0.002$), and being unemployed or retired ($p<0.001$) were positively associated with more time spent within the home. BMI, income, and education were not associated with time spent in each life-space.

Conclusion: The use of technologies to monitor and develop methods to measure life-space mobility is an important step in identifying vulnerable populations that should be targeted for intervention.

INTRODUCTION/BACKGROUND

Among older adults, mobility is one of the most important determinants of good health and well-being (1). As people age, losses in balance, strength, motor skills, sight and hearing have a negative impact on mobility and physical function (2). Two common measures, activities of daily living (ADLs) and instrumental activities of daily living (IADLs), evaluate an individual's ability to carry out daily personal tasks such as going to the bathroom, getting dressed, and meal preparation, as well as activities outside of the home, such as grocery shopping and social activities (3, 4). However, these measures have been criticized for neglecting an important component of mobility, particularly spatial movement through the environment (1, 5).

Life-space is defined as an individual's spatial movement through the environment covered in daily living over a specified period of time (6). Life-space is thought to measure not only physical function, but also characteristics of the environment (e.g. neighborhood, built environment), available resources (e.g. access to transportation, vehicle ownership), intrapersonal factors (e.g. health status, social support) and other contextual factors that influence a person's mobility (7). A constricted life-space has been found to be correlated with chronic disease, (8) depression, (6) and frailty (9). A longitudinal study of Medicare recipients found that a larger life-space predicted lower cognitive decline (10), while a study of community-dwelling older adults found that individuals' with the most constricted life-space (inside the home) had almost twice the risk of developing Alzheimer's disease when compared to individual's with the largest life-space (outside of the neighborhood) (11). These studies have suggested that identifying individuals with a constricted life-space may be helpful in targeting older adults who are at-risk for cognitive decline. While most life-space research has focused on senior populations, identifying early predictors of a restricted life-space in younger adults may be useful when developing preventive interventions.

Disparities in health may be partially explained by differential patterns in life-space, but few studies have investigated if patterns of life space vary according to demographic characteristics such as age, race, education, or marital status. To date, two studies have found lower life-space to be associated with African-American race, male gender, and lower education (9, 10). One study of Medicare recipients found African-American race, female gender, older age and lower

income to all be independently associated with a lower life-space (1), and a study of older Mexican Americans found a lower life-space to be significantly associated with age, female sex, and obesity (BMI $\geq$35 kg/m^2) (12).

All of the life-space studies mentioned above used surveys to collect life-space data; however, life-space surveys are based on self-report and thus prone to recall and reporting bias. Data from global positioning systems (GPS) provide information on speed and altitude aligned with place coordinates, which can be used to objectively measure life-space. Using GPS-based measures of life-space eliminates the inaccuracy of recall bias (13). A few published studies have explored using GPS technologies to characterize life-space in older adults; however, study samples for these studies were small and statistical testing was limited or not conducted (14-18). The primary aim of this study is to use information extracted from GPS trackers to describe associations between life-space and demographic characteristics using a sample of both young and older adults.

METHODS

An exploratory cross-sectional analysis was conducted using data from seven studies provided by the Research in Environment, Active Aging & Community Health (REACH) center at University of California, San Diego: ConTxt, Multilevel Intervention for Physical Activity in Retirement Communities (MIPARC), Reach for Health (RfH), RfH Memory, PALMS007 (Dia por Dia), The UCSD Successful Aging Evaluation Study (SAGE) Daily Behaviors Study, and Cross Transdisciplinary Research on Energetics and Cancer (XTREC).

Study populations

Because three of the seven studies that comprised the analytic sample enrolled only women, the present analyses were restricted to female participants. Details of MIPARC, XTREC, and PALMS007 methods have been reported previously (19-21). In brief, ConTxt and RfH were randomized weight loss intervention trials. ConTxt recruited 21-60 year old obese adults and RfH recruited overweight and obese postmenopausal breast cancer survivors. MIPARC was a randomized physical activity intervention trial among older adults aged 65 years or older living in continuing care retirement communities (CCRCs).

The RfH Memory study was a case-control study nested within the RfH study where participants were normal weight postmenopausal breast cancer survivor controls. PALMS007, SAGE, and xTREC were technology validation studies. PALMS007 recruited Hispanic adults to field test the collection of data using PALMS technology, an algorithm that combines activity, heart rate, and location data from different devices. Older adults, aged 60-100 years, with varying physical health were recruited for the SAGE study to collect pilot data using the Microsoft SenseCam. The purpose of the XTREC study was to test to compare estimates of physical activity using hip and wrist accelerometers and to assess the impact of the built environment in a national sample. Participants were recruited from four XTREC sites: Harvard, Washington University in St. Louis, University of Pennsylvania, and University of California, San Diego. Table 1 contains brief descriptions of the studies and study participants included in this analysis.

Measurement

Demographic variables

Each of the studies collected data on demographic variables using paper surveys administered at baseline. Demographics were standardized across all studies by collapsing categories as follows: marital status (never married, widowed/divorced/separated, presently married), education (≤high school diploma or GED, some college or associate/vocational, college degree, graduate degree), race (African American/Black, Asian, Caucasian/White, Other), income (<30,0000, $30,000-$59,999, >$60,000), employment (unemployed, retired, full-time, part-time). Age and BMI were included in models as continuous variables. MIPARC did not collect data on income or BMI. RfH and RfH Memory did not collect data on income.

Life-space measures

Outcome variables were daily minutes spent in the home, in the neighborhood, and outside the neighborhood. For XTREC participants, home addresses were geocoded and GPS data was converted into three discrete variables: daily minutes spent within the home (within 45meter buffer around home location), within the immediate neighborhood (within 800 meter buffer around home location), and outside of the immediate neighborhood (>800 meters from home location). For all other studies, home address information was not available. Home locations for

each participant were determined by taking the mean center of all GPS coordinates at 3am across wear days. Coordinates that were more than 200m from any other coordinate were excluded from the calculation to reduce outlier days when a participant may have slept in another location.

Life-space variables were collected using the Q1000XT-BT Qstarz GPS monitor for all studies. Participants were asked to wear the GPS monitor for at least 10 hours a day. The monitor was attached to a belt that participants were instructed to wear during all waking hours (i.e., put the belt on upon rising in the morning and remove at bedtime). They were also instructed to charge the monitor at night to ensure the device would not shut off during the day. For all studies except MIPARC, participants were given the option of wearing the GPS device for either 5 days with at least 10 hours of wear time per day or four days with at least 3000 minutes total. MIPARC participants were required to wear devices for four days with at least 10 hours of wear time per day or three days with at least 2400 minutes total. If participants did not meet the wear criteria, they were given another device and asked to wear it for the number of missing days plus one additional day. Participants were included in analyses if they wore the GPS monitor for at least three days with at least 10 hours of wear time per day.

Statistical analysis

Days with less than 10 hours of wear time and participants with less than three days of valid wear were not included in analyses. Prior research has found that at least three days of observation is necessary to estimate habitual activity (22). Somers' D p-values were calculated using the somersd (Newson 2012) package in Stata13 (Version 13.1, StataCorp, College Station, Texas). Somers' D p-values were used to assess associations of life-space measures with demographic variables. For age and BMI, Somer's D coefficients were calculated to measure the strength and direction of the association. For marital status, education, race, income and employment, indicators for each category were created, and Somers' D coefficients were used to measure the association of each category (compared to participants in other categories) with minutes in each life-space zone. P-values test the hypothesis that all coefficients are jointly equal to zero. Data was clustered on participant identifier. Analyses were conducted on individual studies and time spent in each life-space zone was analyzed as a separate dependent variable.

Demographics that were associated with minutes spent in each life-space zone in bivariate analyses were included in multivariable models. P-values less than 0.05 were considered statistically significant and p-values less than 0.10 were considered to be trending towards significance. For multivariable models, data was pooled, and generalized estimating equations (GEE) with an exchangeable correlation matrix and robust standard errors were used to assess the associations of each demographic factor with specific life-space measures. Time spent in each life-space zone was analyzed as a separate outcome, and total minutes of wear time was also included in all models. Since MIPARC participants lived in CCRCs, MIPARC data was analyzed separately from the other studies. All analyses were conducted using Stata13.

RESULTS

Bivariate results

Minutes spent within the home

SAGE and MIPARC participants spent more time in the home than participants from other studies (MIPARC: median (IQR) 498 (319-647) minutes per day, SAGE: median (IQR) 590 (393-726) minutes per day) (Table 2). The median for all of the pooled samples was 400 (IQR: 169-604) minutes per day. PALMS007, UPenn and WUSTL XTREC participants spent the least amount of time in the home.

Employment had the strongest and most consistent association with minutes per day spent in the home with fully employed participants spending the least amount of time in the home in the pooled sample as well as within individual studies ($p<0.001$) (Table 3a). Black participants spent less time in the home and whites spent the most amount of time in the home in the pooled sample ($p=0.038$). White race was associated with more time spent in the home among PALMS007 and UCSD XTREC participants ($p=0.064$, $p=0.031$), but this trend was not seen in any of the other individual studies. In the pooled sample, participants who were never married spent less time in the home ($p=0.001$). This trend was present for most of the individual studies. In the pooled sample, education was not associated with minutes per day spent within the home. However, in all of the studies except for XTREC sites, participants with grade school or high school education spent the most time within the home.

There was a weak positive correlation between age and minutes spent within the home in the pooled sample (*Somer's d*=0.16, p-value<0.001). Age was not correlated with minutes per day spent within the home for any of the individual studies except UCSD XTREC (p=0.042). BMI and income were not associated with minutes per day within the home in the pooled sample or in any individual studies.

Minutes spent within the immediate neighborhood

Participants from all studies except for MIPARC spent very little time in the immediate neighborhood (Table 2). The median time for all the pooled studies was 40 minutes per day (IQR: 9-177 minutes). MIPARC participants had a median of 199 minutes per day (IQR: 92-353 minutes).

Older age (<0.001), being widowed/divorced/separated (p=0.001), being retired (p<0.001) and white race (p=0.04) were positively associated with minutes per day spent in the immediate neighborhood in pooled analysis but not in any individual studies (Table 3b). Education, income, and BMI were not associated with minutes per day spent within the neighborhood for the pooled dataset.

Minutes spent outside the neighborhood

The median time spent outside the neighborhood was 249 (IQR: 55-565) minutes per day. WUSTL XTREC participants spent the most time outside of the neighborhood (median (IQR): 558 (216-642) minutes per day) while MIPARC and SAGE spent the least amount of time outside the neighborhood (MIPARC: 32 (0-151) minutes per day, SAGE: 120 (4-244) minutes per day) (Table 2).

In the pooled sample, participants who worked full-time spent the most time outside the neighborhood (p<0.001). This trend was consistent across most studies (Table 3c). Never married participants in the pooled sample spent more time outside the neighborhood (p<0.001). The opposite trend was true among MIPARC participants with never married participants spending the least amount of time outside the neighborhood (p=0.043).

Black participant in the pooled sample spent the most time outside the neighborhood while white participants spent the least amount of time outside the immediate neighborhood (p=0.004). Education trended towards significance in the pooled sample with participants with college and graduate degrees spending more time outside the immediate neighborhood (p=0.067).

There was a weak negative correlation between age and minutes spent outside the neighborhood among the pooled sample (*Somers' d*=-0.346, p<0.001), but no significant associations were present within any individual study. Income and BMI were not associated with minutes per day spent outside the neighborhood in pooled analysis.

Multivariable results

MIPARC

Race was associated with minutes per day spent within the neighborhood (p=0.005) (Table 4a). Whites spent the most time within the neighborhood and Asians spent the least amount of time within the neighborhood. Marital status was significantly associated with time spent outside the neighborhood with participants who were widowed/divorced/separated spending the most time outside the neighborhood and never married participants spending the least amount of time outside the neighborhood. On average, each additional year of age was associated with 3.75 fewer minutes per day spent outside the neighborhood (p=0.006).

All studies excluding MIPARC

Age, employment, and marital status were associated with total time spent per day within the home. On average, each additional year of age was associated with 2.20 minutes per day spent within the home (p=0.016) (Table 4b). Full-time employed participants spent the least amount of time within the home and unemployed participants spent the most amount of time within the home (p<0.001). Presently married participants spent the most amount of time within the home and never married participants spent the least amount of time within the home (p=0.002). None of the variables were significantly associated with minutes per day spent within the neighborhood.

Age, employment, marital status and race were significantly associated with minutes spent outside the neighborhood. On average, each additional year of age was associated with 2.45 less minutes per day of time spent outside the neighborhood ($p=0.004$). Full-time employed participants spent the most time outside the neighborhood and unemployed spent the least time outside the neighborhood ($p<0.001$). Currently married participant spent the least amount of time outside the neighborhood while never married spent the most time outside the neighborhood ($p=0.003$). Black participants spent the least amount of time outside the neighborhood while "other" race participants spent the most time outside the neighborhood ($p=0.019$).

DISCUSSION

Employment had the strongest and most consistent association with each life-space zone in both bivariate and multivariable analyses. Full-time employed participants spent the least amount of time within the home and the most time outside of the neighborhood. Retired and unemployed participants spent two and three more hours in the home respectively in the pooled sample of all studies excluding MIPARC. Considering that employed individuals travel outside of their home for work, these results are not surprising; however, they highlight that retired and unemployed populations may be at a higher risk of a restricted life-space.

Participants who were currently married spent more time in the home and the least amount of time outside the neighborhood in pooled analysis. This conflicts with prior research that found married participants have greater physical and community mobility (23). A possible explanation for these differences is the difference in study population. The previous analysis focused on seniors while the present study includes younger adults. Among the older MIPARC participants, married participants spent more time outside the neighborhood than never married participants.

There were no significant predictors of time spent in the immediate neighborhood for any studies except for MIPARC. For all other studies, participants spent very little time in the immediate neighborhood. In bivariate analysis, marital status, age, white race and retired employment status were associated with minutes spent in the immediate neighborhood per day in the pooled sample but not in any individual study. These results are likely driven by demographic differences between MIPARC participants and participants in other studies. For example, all of the MIPARC

participants were retired, which drove the significant positive association between retired status and time spent within the neighborhood. There was not enough variability within the MIPARC sample to detect any significant associations within the study. MIPARC participants spent more time in the neighborhood zone which is reflective of them living in CCRCs. Seniors living in CCRCs often have access to social and recreational facilities that fall within the 45-800 meter radius that defines the immediate neighborhood zone (24). These results suggest that specifications used to define the immediate neighborhood zone for this analysis may be too narrow. Modification of the definition of the neighborhood zone should be explored in future studies.

There was very little racial variability among the different samples with whites making up 80% of the sample. Among all studies excluding MIPARC, black participants spent the least amount of time outside the neighborhood. This is consistent with previous analyses that have found African American race to be associated with a more restricted life-space (1, 9, 10, 25). Education was not associated with minutes per day spent in any life-space zone for MIPARC or. This finding also aligns with previous studies that have not found an association between education and life-space (1, 26).

Age was significantly associated with minutes per day within the home and minutes per day outside the immediate neighborhood in the GEE model of all participants excluding MIPARC. Many studies have found positive associations between age and time spent in the home (1, 5, 6, 8-10). Surprisingly, age was not associated with minutes per day spent within the home for MIPARC participants. One possible explanation for this result is that there was not enough variability in age in the MIPARC model to detect an association. Another explanation is that since MIPARC participants, lived on CCRCs, time spent within the CCRC might have been a more meaningful measure.

The major strength of this analysis was that GPS data was used to create objective life-space measures. GPS data are more accurate measures of life-space than scores derived from life-space questionnaires, and few previous studies have used GPS data for these purposes (13). A limitation of this study is that the samples pooled in this analysis had different recruitment

characteristics and exclusion criteria that likely introduced a level of bias into the results (27). Another major limitation is that data on potential confounders was not available across studies and could not be included in multivariable models. Lastly, this analysis is exploratory and results should be seen as preliminary and hypothesis generating.

Even with these limitations, this analysis points to several populations, particularly African Americans and those who are retired and unemployed, who are at a higher risk of a restricted life-space. Some research into early detection of cognitive decline through monitoring of life-space mobility is being conducted. One method that is being developed is continuous monitoring of out-of–home time which uses infrared sensors located in the home to detect whether the resident is at home (28). This method provides continuous, long-term, and unobtrusive monitoring which may provide valuable information on how to detect minute behavior changes that signal changes in cognitive function. Walking speed monitoring with infrared sensors to measure cognitive impairment is also being explored (29). Technologies such as GPS devices and infrared sensors are more accurate methods of data collection and measurement than traditional self-report methods. Given the relationship between restricted life-space and risk of Alzheimer's disease, frailty, cognitive decline and mobility, further research into using technologies to identify groups at risk of a restricted life-space to target for intervention should be explored.

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Table 1 Description of studies that collected data using the Q1000XT-BT model of the Qstarz GPS monitors

Study	Purpose	Participant characteristics	Average GPS wear-days/person	Wear Criteria	Demographic variables available
Contxt	Randomized control trial investigating the role of text message and text message and brief counseling interventions on weight loss after 12 month intervention	21-60 years old, Overweight/ obese BMI≥27	6.1 days	5 days with 10 hrs/day or 4 days with 3000 min	Age, marital status, education, race, income, employment, BMI
MIPARC	Cluster randomized control field trial assessing the efficacy of a 6 month physical activity (PA) intervention to increase minutes of PA among older adults in Continuing Care Retirement Communities (CCRCs)	≥65 years Living on CCRCs	6.7 days	4 days with 10 hrs/day or 3 days with 2400 minutes	Age, marital status, education, race, employment
PALSM007	Field test the collection of data for use in the Personal Activity and Location Measurement System (PALMS) and to validate the PALMS algorithm for trip, transportation mode, and location detection in a free-living Latino population	≥18 years Hispanic adults	4.4 days	5 days with 10 hrs/day or 4 days with 3000 min	Age, marital status, education, race, income, employment, BMI
RfH	Randomized controlled trial with four treatment arms: metformin only, a lifestyle intervention only, both, or neither. Biomarkers of breast cancer recurrence and survival evaluated after 6 months.	Postmenopausal Overweight and obese breast cancer survivors	7.0 days	5 days with 10 hrs/day or 4 days with 3000 min	Age, marital status, education, race, employment, BMI
RfH Memory	Nested case-control study within the RfH trial. Normal weight postmenopausal breast cancer survivors were matched with 80 women from the RfH study. The association between cognition and weight was evaluated.	Postmenopausal Overweight and obese breast cancer survivors	6.5 days	5 days with 10 hrs/day or 4 days with 3000 min	Age, marital status, education, race, employment, BMI
SAGE	Pilot study meant to improve assessments of sedentary behavior and outdoor PA and validate appropriate GPS and accelerometer algorithms	≥60 years with varying physical functioning	5.9 days	5 days with 10 hrs/day or 4 days with 3000 min	Age, marital status, education, race, income, employment, BMI
XTREC	Evaluation of the convergent validity of objective self-reported data on PA, sedentary behavior and sleep using data from multiple cohorts.	**UCSD**: healthy women, 55-75 years **Harvard**: healthy women, 45-75 years **UPenn**: breast cancer survivors, 21-75 years **WUSTL**: healthy women, 21-65 years	6.7 days	5 days with 10 hrs/day or 4 days with 3000 min	Age, marital status, education, race, income, employment, BMI

Table 2 Demographic characteristics and median time spent in each life-space zone by study

	Total	Contxt	MIPARC	PALMS007	RfH	RfH Memory	SAGE	Harvard XTREC	UCSD XTREC	UPENN XTREC	WUSTL XTREC
N	669	46	204	17	117	37	16	28	70	45	78
# of GPS wear days	4,135	292	1,093	76	810	810	89	192	448	324	525
Age, mean (sd)	63.9 (17.5)	41.3 (10.0)	83.6 (6.4)	28.7 (10.7)	61.5 (6.9)	62.8 (7.1)	75.1 (11.0)	59.0 (5.0)	55.4 (15.0)	57.8 (7.9)	49.4 (8.8)
BMI, mean (sd)	29.0 (6.4)	32.6 (3.0)	-	27.0 (7.8)	31.0 (5.3)	22.5 (1.7)	24.5 (3.2)	26.7 (5.4)	29.9 (5.5)	27.3 (4.7)	29.6 (9.2)
Marital status, n (%)											
Never married	62 (9%)	12 (26%)	5 (2%)	10 (59%)	8 (7%%)	1 (3%)	1 (6%)	-	9 (13%)	3 (7%)	13 (17%)
Widowed/divorced/separated	186 (28%)	23 (50%)	85 (42%)	1 (6%)	25 (21%)	5 (14%)	4 (25%)	6 (21%)	17 (24%)	7 (15%)	13 (17%)
Presently married	350 (52%)	11 (24%)	48 (24%)	6 (35%)	84 (72%)	31 (84%)	11 (69%)	22 (79%)	44 (63%)	36 (78%)	52 (67%)
Missing	71 (11%)	-	66 (32%)	-	-	-	-	-	-	-	-
Education, n (%)											
≤HS diploma or GED	82 (12%)	10 (22%)	14 (7%)	12 (71%)	12 (10%)	2 (5%)	2 (13%)	-	10 (14%)	8 (17%)	12 (15%)
Some college	202 (30%)	18 (39%)	69 (34%)	3 (18%)	50 (43%)	8 (22%)	3 (19%)	5 (18%)	18 (26%)	8 (17%)	19 (24%)
College degree	171 (26%)	9 (20%)	57 (28%)	2 (12%)	16 (14%)	7 (19%)	5 (31%)	9 (32%)	21 (30%)	14 (30%)	27 (35%)
Graduate degree	206 (31%)	9 (20%)	56 (27%)	-	39 (33%)	20 (54%)	6 (38%)	14 (50%)	21 (30%)	16 (35%)	20 (26%)
Missing	8 (1%)	-	8 (4%)	-	-	-	-	-	-	-	-
Race, n (%)											
African American/Black	46 (7%)	6 (13%)	1 (0.5%)	-	4 (3%)	-	-	3 (11%)	6 (9%)	2 (4%)	24 (31%)
Caucasian/White	538 (80%)	24 (52%)	184 (90%)	8 (47%)	94 (80%)	31 (84%)	14 (88%)	25 (89%)	53 (76%)	43 (93%)	53 (68%)
Asian	24 (4%)	1 (2%)	10 (5%)	-	3 (3%)	2 (5%)	1 (6%)	-	5 (7%)	1 (2%)	-
Other	45 (7%)	2 (4%)	7 (3%)	9 (53%)	16 (14%)	4 (11%)	1 (6%)	-	6 (7%)	-	1 (1%)
Missing	16 (2%)	13 (28%)	2 (1%)	-	-	-	-	-	1 (1%)	-	-
Income, n (%)											
<$30,000	56 (8%)	17 (37%)	-	8 (47%)	-	-	2 (13%)	-	12 (17%)	1 (2%)	15 (19%)
$30,000-$59,999	70 (10%)	11 (24%)	-	1 (6%)	-	-	4 (25%)	-	12 (17%)	11 (24%)	29 (37%)
>$60,000	130 (19%)	14 (30%)	-	1 (6%)	-	-	10 (63%)	24 (86%)	36 (51%)	30 (65%)	9 (12%)
Missing	413 (62%)	4 (8%)	-	7 (41%)	-	-	-	4 (14%)	10 (14%)	4 (9%)	25 (32%)
Employment, n (%)											
Unemployed	61 (9%)	8 (17%)	-	10 (59%)	22 (19%)	4 (11%)	1 (6%)	1 (4%)	9 (13%)	5 (11%)	-
Retired	294 (44%)	-	204 (100%)	-	31 (27%)	14 (38%)	12 (75%)	4 (14%)	19 (27%)	10 (22%)	-
Full-time	212 (32%)	26 (57%)	-	2 (12%)	43 (37%)	10 (27%)	-	16 (57%)	23 (33%)	21 (46%)	63 (81%)
Part-time	96 (14%)	12 (26%)	-	5 (29%)	21 (18%)	9 (24%)	3 (19%)	6 (21%)	16 (23%)	8 (17%)	15 (19%)
Missing	6 (1%)	-	-	-	-	-	-	1 (4%)	3 (4%)	2 (4%)	-
Min within home, median (IQR)	400 (169-604)	318 (80-583)	498 (319-647)	292 (92-527)	415 (186-618)	456 (247-641)	590 (393-726)	336 (162-573)	323 (49-563)	271 (52-502)	284 (125-471)
Min within neighborhood, median (IQR)	40 (9-177)	10 (4-28)	199 (92-353)	15 (4-46)	14 (5-40)	17 (5-53)	33 (7-95)	41 (9-112)	45 (13-175)	52 (18-260)	23 (7-95)
Min outside neighborhood, median (IQR)	249 (55-565)	513 (195-679)	32 (0-151)	467 (147-678)	326 (132-595)	322 (132-549)	120 (4-244)	438 (198-666)	305 (117-581)	348 (150-597)	558 (216-642)

Table 3a Bivariate analysis of minutes within the home and demographic characteristics

	TOTAL	Contxt	MIPARC	PALMS007	RfH	RfH Memory	SAGE	Harvard XTREC	UCSD XTREC	UPENN XTREC	WUSTL XTREC
p-value	**<0.001****	**0.151**	**0.208**	**0.950**	**0.079***	**0.229**	**0.719**	**0.579**	**0.042****	**0.156**	**0.132**
Age (*Somer's D coeff*)	0.159	0.100	0.045	0.013	0.084	-0.102	0.063	-0.06	0.159	0.143	0.098
Marital status, med (IQR)	**0.001****	**0.354**	**0.298**	**0.950**	**0.071***	**0.884**	**0.074***	**0.304**	**0.011****	**0.067***	**0.586**
Never married	242.5 (17-489)	272 (84-579)	573 (367-644)	332 (58-569)	289 (24-424)	445.5 (252-575)	339 (124-527)		17 (2-195)	0 (0-83)	266.5 (42-410)
Widowed/divorced/separated	411 (169-619)	376 (161-588)	501.5 (325-674)	440 (258-534)	362.5 (92-593)	447 (325-530)	735 (651-810)	180 (3-532)	268 (3-545)	168 (2-363)	292.5 (72-416.5)
Presently married	415 (200-614)	207 (29-537)	549.5 (418-656)	248 (163-487)	447 (226-622)	456 (241.5-647)	546 (375-683)	359 (217-597)	404 (177-611)	314 (125.5-569)	284 (146-498)
Education, med (IQR)	**0.154**	**0.068***	**0.833**	**0.693**	**0.888**	**0.648**	**0.098***	**0.415**	**0.036****	**0.471**	**0.414**
High school diploma or GED	401.5 (148-607)	448.5 (156-588)	542 (276-660)	332 (193-534)	438 (252.5-626)	526 (466-530)	711.5 (668-811)		73 (16-596)	338 (72-673.5)	234 (60-404)
Some college	441 (197-632)	195.5 (27-437)	492.5 (308-645)	296 (89-510)	401 (136-645)	523 (303.5-659)	660.5 (563-790)	425 (264-569)	508 (241-646)	451 (36-644.5)	379 (108-573)
College degree	348 (118-586)	381 (118-705)	507 (322.5-682)	99 (0-328)	402 (170-587)	408 (0-596)	422.5 (144-696)	286 (112-542)	177 (16-363.5)	272 (85-469)	254 (83-395)
Completed graduate degree	396 (188-579.5)	418 (162-617)	480.5 (313-628)	-	415.5 (220-596)	447 (245-629)	516 (331-675)	328 (67-596)	367 (166-545)	200 (34-382)	311 (179-424)
Race, med (IQR)	**0.038****	**0.404**	**0.793**	**0.064***	**0.618**	**0.646**	**0.435**	**0.197**	**0.031****	**0.387**	**0.747**
Black	281 (42-525)	331 (88-599)	487 (449-568)	-	234.5 (2.5-544)	-	-	517 (264-702)	9.5 (1-78)	0 (0-237)	307 (113-522.5)
Asian	442 (134-652)	501 (367-682)	513 (160-708)	-	128 (0-529)	515 (356-647)	676.5 (619-786)	-	261 (112-529)	331 (277-576)	-
White	409 (186-612)	241 (66-542)	500 (317-647)	513 (246-652)	415 (196-618)	456 (245-644)	594 (393-726)	313 (147-562)	378 (172-604)	274 (67.5-518)	269.5 (126-452)
Other	371 (132-527)	468 (289-500)	414 (323-514)	199 (44-328)	439 (200-627)	413 (167-584)	398.5 (282-480)	-	5.5 (0-51)	-	193 (128-402)
Income, med (IQR)	**0.683**	**0.147**	-	**0.558**	-	-	**0.366**	-	**0.038****	**0.214**	**0.416**
<$30,00	305 (84-550)	240.5 (84-532)	-	238 (70-463)	-	-	729.5 (657-835)	-	480 (55-596)	642.5 (486-701)	287 (61-485)
$30,000-$59,999	297.5 (44-520)	142 (27-437)	-	0 (0-0)	-	-	546 (331-692)	-	15.5 (1-301)	358 (153-568)	317 (146-542)
>$60,000	311 (119-550)	405 (165-617)	-	328 (198-531)	-	-	558.5 (371-684)	373 (203-624)	341 (166-579)	195 (7-435)	216 (83-394)
Employment, med (IQR)	**<0.001****	**0.014****	-	**0.034****	**<0.001****	**<0.001****	**0.666**	**0.028****	**0.008****	**0.294**	**0.004****
Unemployed	515.5 (332-657)	590.5 (437-734)	-	487 (248-601)	504 (297-647)	539.5 (441-638)	664 (484-790)	488 (400-679)	542 (418-646)	302.5 (2-657)	-
Retired	499 (298-654)	-	-	-	569 (370-713)	446 (0-619)	563 (375-724)	518 (166-651)	391 (121-595.5)	467 (34-641)	-
Full-time	243.5 (82-445)	257 (56-535)	-	0 (0-196)	249 (133-459)	453 (261-643)		239 (17-420)	194 (35-365)	180 (42.5-327)	251 (91-422)
Part-time	387 (189-569)	226 (52-500)	-	197 (0-268)	417 (254-612)	428 (287-681)	649 (354-683)	525 (287-692)	350 (7-551)	342 (164-487.5)	407 (257-525)
p-value	**0.128**	**0.963**	-	**0.534**	**0.194**	**0.849**	**0.216**	**0.353**	**0.092***	**0.148**	**0.638**
BMI (*Somers' D coeff*)	-0.041	0.004	-	0.097	0.066	0.022	0.167	-0.106	-0.125	0.143	0.028

*p-value<0.10
**p-value<0.05

Table 3b Bivariate analysis of minutes within the immediate neighborhood and demographic characteristics

	TOTAL	Contxt	MIPARC	PALMS007	RfH	RfH Memory	SAGE	Harvard XTREC	UCSD XTREC	UPENN XTREC	WUSTL XTREC
p-value	**<0.001****	**0.268**	**0.560**	**0.124**	**0.717**	**0.563**	**0.782**	**0.402**	**0.526**	**0.824**	**0.256**
Age (*Somer's D coeff*)	0.243	0.067	0.021	0.228	0.016	-0.053	-0.058	0.101	0.050	-0.021	-0.081
Marital status, med (IQR)	**<0.001****	**0.371**	**0.774**	**0.124**	**0.804**	**0.637**	**0.645**	**0.446**	**0.629**	**0.158**	**0.822**
Never married	25 (6-95)	8 (4-23)	170 (68-446)	13 (2-40)	14 (1-65)	56 (14-113)	69 (33-95)	-	64 (13-373)	414 (33-853)	26 (13-67)
Widowed/divorced/separated	68.5 (11-224)	13 (5-45)	178 (85-338)	15 (5-21)	15 (6-64)	26 (6-47)	28 (7-66)	76 (12-245)	57 (18-264)	102 (44-309)	13 (6-70)
Presently married	28 (8-109)	9 (3-20)	172 (92.5-278.5)	33 (10-105)	13 (5-36)	17 (4-53)	32 (7-116)	32 (9-97)	39 (12-133)	42.5 (17-178.5)	24 (6-109)
Education, med (IQR)	**0.579**	**0.433**	**0.443**	**0.825**	**0.780**	**0.937**	**0.061**	**0.666**	**0.607**	**0.187**	**0.870**
High school diploma or GED	31 (8-160)	11 (4.5-26.5)	225 (140-386)	16 (4-55)	17.5 (6-61)	21 (9-64)	2 (0-8)	-	213 (23-587)	26 (9-64.5)	18 (7-68)
Some college	36 (8-159)	9 (2-26)	186 (82-328)	13 (10-28)	15 (5-42)	16.5 (6.5-42)	7.5 (5-59)	33 (13-53)	47 (14-121)	42 (19.5-192.5)	21 (6-100)
College degree	47 (10-191)	8 (5-22)	174.5 (89-384)	7 (2-33)	12 (5-31)	14 (2-69)	31.5 (9-92)	34.5 (11-132.5)	36.5 (14-154)	49 (15-211)	26 (8-160)
Graduate degree	44 (10-184.5)	15 (7-51)	223 (93.5-384.5)		12 (5-36)	17 (4-53)	94 (41-280)	51 (8-184)	30 (12-138)	107 (31-367)	30 (7-62)
Race, med (IQR)	**0.038****	**0.272**	**0.408**	**0.736**	**0.258**	**0.692**	**0.406**	**0.204**	**0.403**	**0.502**	**0.440**
Black	24 (8-107)	17 (5-33)	236.5 (200-311)	-	43.5 (13-670.5)	-	-	20 (8-44)	160 (22-453)	411 (22-704)	18.5 (6-52)
Asian	33 (7-127)	5 (0-10)	109 (32-311)	-	4 (0-10)	24 (5-60)	95 (42-133)	-	20 (5-88)	17 (15-27)	-
White	49 (10-200)	8 (4-20)	204 (97-367)	15.5 (4-60)	14 (5-40)	18 (5-64)	30 (7-89)	44 (10-140)	44.5 (13-138)	52 (19.5-249.5)	27.5 (7-116)
Other	22 (7-82)	48 (7-85)	161 (67-291)	12.5 (5-40)	13.5 (5-32)	12.5 (5-29)	259.5 (116-343)	-	248.5 (22-549)	-	7 (5-30)
Income, med (IQR)	**0.168**	**0.330**	-	**0.533**	-	-	**0.885**	**-**	**0.147**	**0.205**	**0.910**
<$30,000	23 (7-68)	13.5 (5-33)	-	17 (7-43)	-	-	23 (4-66)	-	65 (23-246)	20.5 (12-32)	19 (7-57)
$30,000-$59,999	22 (6-126)	8 (3-20)	-	2 (0-3)	-	-	10 (2-428)	-	57 (17-532)	36 (16-116)	22 (5-148)
>$60,000	33 (10-101)	10.5 (6-47)	-	33 (11-58)	-	-	34 (11-92)	27 (8-69)	31 (11-105)	70 (24-369)	23 (9-40)
Employment, med (IQR)	**<0.001****	**0.331**	-	**0.782**	**0.077***	**0.077***	**0.281**	**0.540**	**0.343**	**0.354**	**0.808**
Unemployed	27 (11-82)	18.5 (5-36)	-	20.5 (5-45)	26 (10-65)	40 (17.5-62)	5 (0-7)	108 (90-131)	43.5 (18-91)	184.5 (34-608)	-
Retired	127 (26-298)		-	-	13 (4-43)	10 (0-34)	59 (10-156)	66 (19-457)	82 (17.5-299)	104 (25-413)	-
Full-time	18 (6-60)	9 (4-25)	-	0 (0-47)	11 (5-31)	13 (5-82)	-	29.5 (6-86)	27 (11-87)	39 (16-123.5)	23 (6-107)
Part-time	23 (7-76)	8 (5-36)	-	11 (5-47)	12 (6-32)	35 (11-99)	27 (2-52)	56 (10-158)	27 (10-142)	53 (27.5-299)	24 (7-68)
p-value	**0.481**	**0.612**	-	**0.798**	**0.360**	**0.398**	**0.197**	**0.295**	**0.136**	**0.037****	**0.539**
BMI (*Somers' D coeff*)	-0.019	-0.030	-	0.044	0.018	0.096	0.169	-0.122	0.106	-0.186	0.044

*p-value<0.10
**p-value<0.05

Table 3c Bivariate analysis of minutes outside the immediate neighborhood and demographic characteristics

	TOTAL	Contxt	MIPARC	PALMS007	RfH	RfH Memory	SAGE	Harvard XTREC	UCSD XTREC	UPENN XTREC	WUSTLR XTREC
p-value	**<0.001****	**0.319**	**<0.001****	**0.910**	**0.024****	**0.627**	**0.025****	**0.511**	**0.005****	**0.042****	**0.488**
Age (*Somer's D coeff*)	-0.346	-0.067	-0.158	-0.022	-0.095	0.042	-0.328	-0.067	-0.172	-0.125	0.033
Marital status, med (IQR)	**<0.001****	**0.465**	**0.043****	**0.910**	**0.364**	**0.612**	**0.134**	**0.326**	**0.145**	**0.785**	**0.084***
Never married	473.5 (139-655)	520.5 (106-677)	0 (0-66)	394 (116-689)	556 (229-782)	222.5 (134-307)	389 (143-565)	-	464.5 (181-664)	380 (139-636)	578 (413-709)
Widowed/divorced/separated	165 (2-501)	432 (204-652)	17 (0-129)	417.5 (246-594)	295 (92-581)	340 (181-484)	1 (0-112)	621 (239-676)	373 (147-615)	385 (193-671)	564 (444-643)
Presently married	293 (96-579)	590 (291-722)	53 (0-172.5)	470 (242-689)	322 (138-580)	325 (117-563.5)	147 (66-244)	424 (177-665)	263 (92-507)	340 (143.5-574)	532 (169-635)
Education, med (IQR)	**0.067***	**0.226**	**0.172**	**0.506**	**0.472**	**0.666**	**0.124**	**0.961**	**<0.001**	**0.824**	**0.176**
≤HS diploma	232.5 (64-585)	316 (108.5-591)	7 (0-114)	394 (116-669)	216.5 (90-571)	223 (162-399)	58.5 (0-192)		151 (46-394)	370 (111-602)	597 (524-664)
Some college	204 (29-488)	604.5 (353-709)	33.5 (0-154)	410 (271-650)	303 (99-585)	266 (128-449)	51.5 (0-95)	465.5 (265-665)	184 (37-359)	277 (142.5-490)	469.5 (31-604)
College degree	263 (52-592)	523 (112-678)	10 (0-134)	627.5 (592-829)	357 (161-622)	358 (156-834)	236 (78-475)	482 (203-633.5)	583 (267.5-706)	327 (147-601)	537 (203-652)
Graduate degree	290.5 (84.5-568)	390 (207-647)	53.5 (0-171)		356.5 (177-603)	327 (106-584)	126 (1-226)	404 (185-695)	303 (144-565)	387 (183-607)	568 (346-635)
Race, med (IQR)	**0.004***	**0.680**	**0.029****	**0.022****	**0.286**	**0.274**	**0.573**	**0.928**	**0.797**	**0.712**	**0.636**
Black	446 (150-631)	542 (150-659)	21 (6-120)	-	179.5 (0-463)	-	-	418 (165-695)	350.5 (91-662.5)	293 (161-555)	556 (245-637)
Asian	229 (98-510)	226.5 (0-384)	126 (2-270)	-	693 (406-879)	222.5 (134-307)	0.5 (0-126)	-	273.5 (147-603)	470 (266-554)	-
White	227 (42-549)	579 (257-694)	25 (0-144)	244 (73-607)	327 (140-599)	324 (123-558)	122 (19-256)	443 (204-660)	281 (104-565)	348 (143-603.5)	561 (216-644)
Other	340 (124-573)	424 (266-610)	62 (0-217)	598.5 (344-789)	310 (105-569)	437 (215-634)	102.5 (69-331)	-	443 (217-676)	-	527 (210-564)
Income, med (IQR)	**0.719**	**0.381**	**-**	**0.665**	**-**	**-**	**0.187**	**-**	**0.199**	**0.597**	**0.020**
<$30,000	471 (174-633)	536.5 (195-698)	-	481 (271-771)	-	-	11.5 (0-108)	-	271 (109-396)	83 (0-133)	579 (403-645)
$30,000-$59,999	413 (123-624)	597.5 (362-706)	-	829 (622-988)	-	-	117 (0-192)	-	387.5 (139-639)	319 (170-579)	439 (22-604)
>$60,000	409 (169-624)	423 (207-638)	-	592 (341-633)	-	-	171 (59-324)	514 (206-687)	320 (134-599)	379 (161-615)	571 (472-683)
Employment, med (IQR)	**<0.001****	**0.009****	**-**	**0.018****	**<0.001****	**<0.001****	**0.636**	**0.002****	**<0.001****	**<0.001****	**0.055***
Unemployed	215 (84-364)	155.5 (48-353)	-	288 (85-530)	204 (75-350)	348 (176-447.5)	84 (0-195)	371 (117-532)	219 (113-324)	192.5 (96-313)	-
Retired	92 (0-240)		-	-	205 (73-361)	340 (170-815)	120 (9-226)	213 (154.5-318)	196.5 (56-374.5)	162 (55-287)	-
Full-time	574 (275-678)	590 (218-704)	-	789 (686-933)	569 (308-668)	324 (91-536)		621 (414-708.5)	608 (303-685)	564 (332-696.5)	572 (220-646)
Part-time	357 (159-570)	510 (282-703)	-	627 (471-691)	350 (122-516)	245 (108-419)	244 (0-485)	270 (93-461)	271 (143-498)	373 (236-577)	452 (166-579)
p-value	**0.186**	**0.938**	**-**	**0.688**	**0.802**	**0.904**	**0.804**	**0.346**	**0.084***	**0.974**	**0.967**
BMI (*Somers' D coeff*)	0.033112	0.0062326	-	-0.0628159	-0.0127027	-0.0140921	0.0372437	0.0834917	0.1033083	-0.0022947	-0.002132

*p-value<0.10
**p-value<0.05

Table 4a GEE model of minutes spent in each life-space zone and demographic predictors for MIPARC participants only, GPS wear-days clustered on participant id

N=135 # of GPS wear days=773	**Minutes within the home**			**Minutes within the immediate neighborhood**			**Minutes outside the neighborhood**		
	Coeff	95% CI	p-value	Coeff	95% CI	p-value	Coeff	95% CI	p-value
Total minutes	0.65	(0.50, 0.79)	**<0.001**	0.19	(0.07, 0.31)	**0.002**	0.16	(0.05, 0.28)	**0.006**
Age	3.81	(-1.29, 8.91)	**0.159**	-0.14	(4.35, 4.06)	**0.947**	-3.75	(-6.83, -0.66)	**0.017**
Marital Status			**0.430**			**0.397**			**0.007**
Presently married	Ref	Ref		Ref	Ref		Ref	Ref	
Never married	4.36	(-195.40, 204.12)		54.09	(-144.96, 253.14)		-56.51	(-97.16, -15.86)	
Widowed/divorced/separated	-36.01	(-92.35, 20.33)		32.95	(-15.54, 81.45)		3.81	(-31.51, 39.13)	
Race			**0.636**			**0.005**			**0.178**
White	Ref	Ref		Ref	Ref		Ref	Ref	
Asian	22.36	(-38.31, 83.02)		-108.51	(-175.10, -41.93)		84.27	(-4.75, 173.30)	
Other	52.95	(-117.11, 223.01)		-47.91	(-170.23, 74.41)		-3.16	(-72.44, 66.13)	
Education			**0.777**			**0.605**			**0.291**
≤High School or GED	Ref	Ref		Ref	Ref		Ref	Ref	
Some college	36.64	(-63.05, 136.34)		-62.66	(-154.98, 29.67)		25.80	(-24.77, 76.37)	
College degree	54.69	(-49.18, 158.55)		-45.73	(-145.21, 53.74)		-8.41	(-47.41, 30.59)	
Graduate degree	34.86	(-63.91, 133.64)		-51.18	(-144.80, 42.44)		16.09	(-24.96, 57.14)	

Table 4b GEE model of minutes spent in each life-space zone and demographic predictors for all studies excluding MIPARC, GPS wear-days clustered on participant id

N=439 # of GPS wear days=2,887	**Minutes within the home**			**Minutes within the immediate neighborhood**			**Minutes outside the neighborhood**		
	Coeff	95% CI	p-value	Coeff	95% CI	p-value	Coeff	95% CI	p-value
Total minutes	0.19	(0.10, 0.28)	**<0.001**	0.06	(0.01, 0.11)	**0.018**	0.73	(0.63, 0.83)	**<0.001**
Age	2.20	(0.37, 3.97)	**0.018**	0.36	(-0.93, 1.65)	**0.224**	-2.44	(-4.09, -0.80)	**0.004**
Employment			**<0.001**			**0.224**			**<0.001**
Full-time	Ref	Ref		Ref	Ref		Ref	Ref	
Unemployed	181.77	(123.43, 240.12)		28.67	(-19.08, 76.41)		-209.60	(-257.95, -161.24)	
Retired	121.15	(58.22, 184.08)		44.33	(-2.76, 91.42)		-164.05	(-220.65, -107.45)	
Part-time	88.11	(42.19, 134.03)		18.05	(-18.22, 54.31)		-114.99	(-154.36, -75.63)	
Marital status			**0.002**			**0.483**			**0.003**
Presently married	Ref	Ref		Ref	Ref		Ref	Ref	
Never married	-85.93	(-147.93, -23.93)		-1.93	(-50.51, 46.65)		93.42	(34.76, 152.08)	
Widowed/divorced/separated	-64.38	(-112.83, -15.94)		23.35	(-15.09, 61.79)		41.50	(2.87, 80.12)	
Race			**0.442**			**0.140**			**0.019**
White	Ref	Ref		Ref	Ref		Ref	Ref	
Black	24.50	(-41.22, 90.22)		22.51	(-34.45, 79.47)		-46.05	(-100.13, 8.02)	
Asian	-14.80	(-124.21, 94.61)		-40.15	(-79.22, -1.08)		-2.46	(-116.62, 111.70)	
Other	-40.20	(-101.72, 21.31)		-21.24	(-72.67, 30.19)		62.28	(8.37, 116.19)	
Education			**0.081**			**0.268**			**0.333**
≤High school or GED	Ref	Ref		Ref	Ref		Ref	Ref	
Some college	1.48	(-61.75, 64.72)		-25.66	(-73.81, 22.50)		19.85	(-32.29, 71.99)	
College degree	-62.00	(-127.90, 3.89)		13.24	(-40.24, 66.73)		50.22	(-5.46, 105.90)	
Graduate degree	-19.05	(-82.59, 44.49)		0.02	(-50.11, 50.14)		21.19	(-29.78, 72.17)	