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A prospective investigation of neighborhood socioeconomic deprivation and physical activity and sedentary behavior in older adults

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Abstract

Neighborhood conditions may have an important impact on physical activity and sedentary behaviors in the older population. Most previous studies in this area are cross-sectional and report mixed findings regarding the effects of neighborhood environment on different types of physical activity. Moreover, little is known about the prospective relationship between neighborhood environment and sedentary behaviors. Our analysis included 136,526 participants from the NIH-AARP Diet and Health Study (age 51–70). Neighborhood socioeconomic deprivation was measured with an index based on census variables and developed using principal component analysis. Physical activity and sedentary behaviors were measured both at baseline (1995–1996) and follow-up (2004–2006). Multiple regression analyses were conducted to examine the prospective relationship between neighborhood deprivation and exercise, non-exercise physical activity, and sedentary behaviors, adjusting for baseline physical activity and sedentary behaviors as well as potential confounders. We found that more severe neighborhood socioeconomic deprivation was prospectively associated with reduced time for exercise ($\beta_{Q5 \text{ vs } Q1}$ (95% confidence interval), hour, −0.85 (−0.95, −0.75)) but increased time spent in non-exercise physical activities (1.16 (0.97, 1.34)), such as household activities, outdoor chores, and walking for transportation. Moreover, people from more deprived neighborhoods were also more likely to engage in prolonged (≥5 h/day) TV viewing (Odds ratio $_{Q5 \text{ vs } Q1}$ (95% confidence interval), 1.21 (1.15, 1.27)). In conclusion, neighborhood socioeconomic deprivation is associated with physical

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Conflict of interest

The authors declare no conflict of interest.

Appendix A. Supplementary data

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activity and sedentary behavior in the older population. These associations may differ for different types of physical activities.

Keywords

Neighborhood socioeconomic deprivation; Health disparities; Aging; Physical activity; Sedentary behavior

1. Introduction

Maintaining regular physical activity and avoiding prolonged sedentary behavior have numerous health benefits and are crucial for healthy aging (Stewart et al., 2015). Despite the well-known benefits of exercise, physical inactivity is highly prevalent among the older population. A recent study using three national surveys in the US estimated that only 27% to 44% of older adults meet activity guidelines of 150 min of moderate-to-vigorous physical activity or 75 min of vigorous activity throughout the week (Keadle et al., 2016). There are also health risks associated with too much sitting (Keadle et al., 2015), and yet older adults (age 60 or older) spend an average of 60% of their waking time in sedentary behavior (Matthews et al., 2008). The public health burden associated with low physical activity and excessive sedentary behavior is an important concern in the aging population and therefore it is important to identify factors that shape the physical activity pattern in older adults.

Like many health behaviors, physical activity and sedentary behavior are affected not only by individual factors but also the characteristics of the environment in which older adults live (Satariano, 2006; Satariano and McAuley, 2003). Because of declines in physical and mental functioning, decrease in social contact, and increased difficulties with driving, people become increasingly confined to their immediate residential environment as they age. As a result, the neighborhood environment may play a particularly important role in shaping health behaviors in the older population. Two recent systematic reviews synthesized previous findings from a wide variety of studies and reported a number of relevant associations between some aspects of the neighborhood environment and physical activity and sedentary behavior in the older population (Chastin et al., 2015; Van Cauwenberg et al., 2011). For example, characteristics associated with disadvantaged neighborhood environments, such as lack of commercial services and recreational facilities, high crime rates and poor safety have been linked to lower levels of physical activity, and prolonged sedentary behavior (Chad et al., 2005; Chastin et al., 2014; Piro et al., 2006; Van Cauwenberg et al., 2014; Wilcox et al., 2003). However, 48 of the 53 studies included in these reviews were cross-sectional in nature, so the temporal relationship between neighborhood environments and relevant behaviors remains uncertain. The few longitudinal studies available have noted that proximity to parks and trails, access to physical activity facilities, and safe walking environments were associated with more physical activity in older adults (Li et al., 2005; Michael et al., 2010); but another study found no prospective relationship between walking and urban sprawl in older men (Lee et al., 2009). To the best of our knowledge, there has been no prospective investigation on neighborhood characteristics and sedentary behavior in older populations. Furthermore, both aforementioned reviews emphasized the need for

future studies to focus on specific types of physical activity and sedentary behaviors, because neighborhood environment may have different effects on different types and domains of physical activity and sedentary behavior.

To address the limitations in the literature, we prospectively investigated the relationship between neighborhood socioeconomic deprivation characterized using commonly available census data and detailed measures of physical activity and sedentary behavior in a large cohort of middle-to-old aged US men and women. Based on the findings from previous studies, we hypothesize that more severe neighborhood socioeconomic deprivation is associated with lower levels of physical activity and prolonged sedentary time. We also hypothesize that the associations may differ by types of exercise, non-exercise activity, and sedentary behaviors.

2. Methods

2.1. Study population

Details of the NIH-AARP study were reported previously (Schatzkin et al., 2001). Briefly, the NIH-AARP Diet and Health Study recruited AARP members who were 50 to 71 years old and resided in one of six US states (California, Florida, Louisiana, New Jersey, North Carolina, and Pennsylvania) and two metropolitan areas (Atlanta, Georgia, and Detroit, Michigan) in 1995–1996. In total, 566,399 participants satisfactorily completed the baseline questionnaire. Within 6 months of the baseline, a risk factor questionnaire was mailed to the cohort; and in 2004–2006, an additional follow-up questionnaire was mailed to baseline participants. Residential address was reported at baseline, and in 2004, the Study compiled a list of updated addresses in preparation for mailing the follow-up questionnaire. Information on physical activity and sedentary behavior was reported in both risk factor and follow-up questionnaires. Of the 221,189 participants who completed all three questionnaires, we excluded those with no baseline neighborhood information ($N = 224$), missing physical activity and sedentary behavior information at baseline ($N = 3819$) or follow-up ($N = 78,043$). We further excluded those who had emphysema and end-stage renal disease at baseline ($N = 2577$). The final analytic cohort consisted of 136,526 participants. The study was approved by the National Cancer Institute Special Studies Institutional Review Board.

2.2. Area-level socioeconomic deprivation

Baseline addresses were geocoded to latitude/longitude and linked to the 2000 US Census at the census tract level. We applied the method developed by Messer et al. (2006). to generate an empirical neighborhood socioeconomic deprivation index (Doubeni et al., 2012). In brief, we selected 19 census tract variables that were related to seven components of the neighborhood environment (housing characteristics, residential stability, poverty, employment, occupation, racial composition, and education). We performed principal component analysis (PCA) on these 19 variables, stratified by state, and we retained ten variables with consistent high loadings across states (% total with less than high school education, % non-Hispanic blacks, % total unemployed, % females in management, % males in management, % households with income (1999) below poverty, % female head of household, % households with public assistance income, % households with income < 30k,

% households with no vehicle). Finally, we calculated the neighborhood socioeconomic deprivation index for each census tract by summing the PCA loadings of these ten variables and categorized it into quintiles for analysis. Distributions of census variables used in the deprivation index in this population according to state of residence are presented in Supplementary Table 1.

2.3. Assessment of physical activity and sedentary behavior

We used information collected in the risk factor questionnaire to measure baseline levels for physical activity and sedentary behavior. In the questionnaire, participants were given a list of examples of "moderate and vigorous" recreational and household activities (MVPA), and were asked to indicate how often (never, rarely, weekly but < 1 h per week, 1–3 h per week, 4–7 h per week, and > 7 h per week) they participated in these activities in the past 10 years (questionnaire is presented in the Supplementary Fig. 1). Participants also reported the amount of time they spent in a typical day sitting overall (< 3, 3–4, 5–6, 7–8, and ≥9 h) and watching television or videos (none, < 1 h, 1–2, 3–4, 5–6, 7–8, and ≥9 h), during the past year.

The follow-up questionnaire asked "During the past 12 months approximately how much time each week did you participate in each of the following activities?", and 16 activities were listed as were response options for each activity (None, 5 min, 15 min, 30 min, 1 h, 1.5, 2–3, 4–6, 7–10, > 10 h). Activities were classified as exercise activities (walking for exercise, jogging or running, playing tennis, squash or racquetball, playing golf, swimming, bicycling, other aerobic exercise and weight training) and non-exercise activities (light household chore, moderate to vigorous household chore, moderate outdoor chores, vigorous outdoor chores, house repair, caring for children, caring for another adult, walking for daily activities; see Supplementary Fig. 2). The follow-up questionnaire also asked about the average number of hours spent "in a typical 24-hour period during the past 12 months" in three sitting behaviors: Sitting watching television/video/DVD; Sitting or driving in a car bus or train; and Other sitting-reading, knitting, using computer (None, < 3, 3–4, 5–6, 7–8, 9–10, 11–12, or ≥12 h).

2.4. Covariates

The baseline questionnaire collected information on a broad range of covariates, including demographic characteristics, smoking history, alcohol consumption, the use of dietary supplements and non-steroidal anti-inflammatory drugs, sleep duration and menopausal hormone therapy in women. Diet was measured using a 124-item food-frequency questionnaire. Participants reported their current height (in inches and feet) and weight (in pounds) at baseline. We calculated body-mass index (BMI) as the weight at these respective times divided by baseline height squared (kg/m^2). Both the baseline and follow-up questionnaires asked about medical history on conditions including cancer, cardiovascular disease, and diabetes. Additionally, incident cancer cases were identified through linkage to eight original and three additional (Arizona, Nevada, and Texas) state cancer registry databases. Age at retirement was assessed by the follow-up questionnaire.

2.5. Statistical analysis

We assigned a numeric value for each categories of physical activity (0 for “None”, 0.083 for “5 min”, 0.25 for “15 min”, 0.5 for “30 min”, 1 for “1 h”, 1.5 for “1.5 h”, 2.5 for “2–3 h”, 5 for “4–6 h”, 8.5 for “7–10 h” 10 for “10 h”) and sedentary behaviors (0 for ‘None’, 1.5 for “< 3 h”3.5 for “3–4 h”, 5.5 for “5–6 h”, 7.5 for “7–8 h”, 9.5 for “9–10 h” 11.5 for “11–12 h” and 12 for “> 12 h”). We then calculated continuous variables for the total hours per week spent on exercise activities, non-exercise activities, total activities, and total sedentary time separately by summing the numeric value for each individual variable in the levant class. We also derived several dichotomous variables for physical activity (< 1 h/week, yes or no) and sedentary behavior (prolonged time spent on each of the three sedentary activities, loosely based the cut-off for the highest quintile, yes vs no: watching TV, ≥5 h; driving, ≥3 h; other sitting, ≥5 h and total sitting, ≥10 h).

We used linear regression for continuous outcomes and logistic gression for dichotomous outcomes. We considered a series of multivariable regression models: The base model was adjusted for age (continuous), sex (male, female) and baseline MVPA (never, rarely, 1, 1–3, 4–7, and > 7 h per week, for physical activity outcomes) or TV viewing (< 1, 1–2, 3–4, 5–6, 7–8, ≥9 h./day, for sedentary behavior outcomes). In a second model, we further adjusted for potential confounders, which include indicators of race (non-Hispanic white, non-Hispanic black, Hispanic, Asian or Pacific Islander or American Indian/Alaskan Native, other), education (< 12 years, 12 years, post-high school, some college, college/post-graduate, unknown), marital status (married, not married), retirement status at baseline (retired, not tired), self-rated health (excellent, very good, good, fair, poor), state residence (CA, FL, LA, NJ, NC, PA, GA, MI), as well as baseline medical history (yes, no) of heart disease, stroke, cancer and diabetes. We also performed sensitivity analysis by restricting to participants who did not move from their neighborhood between baseline and follow-up (de-fined as < 1 km in distance between the follow-up address and baseline address, $N = 72{,}339$).

3. Results

Baseline study characteristics by quintiles of neighborhood socioeconomic deprivation are presented in Table 1. When compared those from the least deprived neighborhood, participants from more deprived neighborhood were more likely to be women and black and report current smoking, while they were less likely to be married have a college education. Residents of more deprived neighborhoods also had higher prevalence of heart disease, stroke and diabetes baseline. Cross-sectional analysis showed that more severe neighborhood deprivation was associated with higher odds of reporting low levels of MVPA (< 1 h/week, $OR_{Q5\ vs\ Q1}$ (95% CI), 1.18 (1.13, 1.23)) and prolonged TV viewing (≥5 h/day, 1.28 (1.21, 1.35)) at baseline (Supplementary Table 2).

We next examined the prospective relationship between baseline neighborhood deprivation and exercise at follow up, and the findings suggested an inverse association (Table 2): when compared with the participants in the least deprived neighborhoods, those in the most deprived neighborhoods reported on average spending about 50 min/week less time exercising ($\beta_{Q5\ vs\ Q1}$ (95% CI), hour/week, 5 (−0.95, −0.75)). When we restricted our

analysis to people who reported living in the same neighborhood at baseline and follow-up, our results were unchanged (< 1% difference in effect estimates, data not shown).

In contrast to exercise, non-exercise physical activity including household and outdoor chores, caregiving and walking for transportation was positively associated with neighborhood socioeconomic deprivation (Table 2). On average, participants in the most deprived quintiles of neighborhood deprivation spent over 1 h more on non-exercise physical activity per week (($\beta_{Q5\ vs\ Q1}$ (95% CI), hour/week, 1.13(0.94, 1.32)). When we further examined the individual non-exercise activities, we found that 7 of 8 activities were positively associated with neighborhood socioeconomic deprivation (Table 3). The association was particularly strong for outdoor chores such as mowing, gardening and snow shoveling ($\beta_{Q5\ vs\ Q1}$ (95% CI), hour/week, 0.29 (0.24, 0.34) and 0.23 (0.19, 0.27)) for moderate and vigorous outdoor chores, respectively). Although participants were instructed to report only non-occupational activities, we were concerned about the possibility of contamination from work-related physical activity in the reporting of non-exercise physical activity. Therefore, we examined these results by retirement status and found that more severe neighborhood socioeconomic deprivation was associated with higher levels of non-exercise physical activities regardless of retirement status, although the association appeared to be stronger among those who were still working (Supplementary Table 3). After we combined the time spent on both exercise and non-exercise activities as total physical activity, we found that this measure was positively associated with neighborhood socioeconomic deprivation. On average, people in the most deprived neighborhoods spent 26 min/week more in total physical activity than their counterparts from the least deprived neighborhoods (Supplementary Table 4).

Finally, we examined the prospective relationship between baseline neighborhood socioeconomic deprivation and time spent on sedentary behavior reported at follow-up (Table 4). More severe neighborhood deprivation was associated with higher odds of prolonged TV viewing and driving ($OR_{Q5\ vs\ Q1}$ (95% CI), 1.21 (1.15, 1.27) for TV viewing for 5+ hours/day, and 1.26 (1.20, 1.32) for driving for 3+ hours/day). In contrast, we found a slight decrease in odds of reporting prolonged (5+ hours/day) other sitting activities (reading, knitting, using computer) with increased neighborhood deprivation ($OR_{Q5\ vs\ Q1}$ (95% CI), 0.91 (0.87, 0.96)). Overall, higher neighborhood socioeconomic deprivation was associated with a small increase in the odds of reporting prolonged total sitting (10+ hours/day) at follow up ($OR_{Q5\ vs\ Q1}$ (95% CI), 1.08 (1.04, 1.13)). Restricting the analysis to people who reported living in the same neighborhood at baseline and follow-up had little impact on our findings (< 1% change in effect estimates, data not shown).

4. Discussion

In a cohort of middle-to-old aged men and women in the US, we found that more severe socioeconomic deprivation in the neighborhood was prospectively associated with less reported exercise but increased time spent in non-exercise physical activities, such as household activities, outdoor chores, and walking for transportation. Moreover, people from more deprived neighborhoods were also more likely to engage in certain sedentary behaviors, specifically TV viewing and driving.

Although numerous studies have examined the relationship between neighborhood characteristics and physical activity in the older population, their findings are mixed. A recent systematic review summarized 31 studies and found that the majority of the published associations were non-significant (Van Cauwenberg et al., 2011). The authors argued that lack of consistency and significant findings may be due to methodological limitations of the existing literature, particularly the fact that many studies focused on total physical activity as the primary outcome measure, without considering potentially heterogeneous effects on different types of physical activity as noted in some previous studies (Sallis et al., 2006). Use of an aggregated measure of total physical activity may mask more complex relationships that might be revealed by analyzing different types of physical activity separately. Indeed, we found countervailing associations of neighborhood socioeconomic deprivation on exercise and non-exercise physical activities, supporting the need for future studies to focus on specific types of activity when evaluating the influence of neighborhood characteristics on physical activity behaviors.

We found that lower neighborhood socioeconomic status was associated with lower levels of exercise, and this finding is consistent with several previous cross-sectional studies: A recent study in Chicago reported that a better neighborhood social environment characterized by higher neighborhood socioeconomic status (SES) and social capital was positively associated with regular exercise in the past year (Wen and Zhang, 2009). Another study also reported lower leisure-time physical activity (−47.8 MET·min/day) among women living in the most deprived neighborhoods in Porto, Portugal (Alves et al., 2013). Associations in both of these studies persisted after controlling for factors related to individual-level socioeconomic status. Several mechanisms could explain the impact of neighborhood deprivation on exercise: less affluent neighborhoods tends to have worse public safety and less access to neighborhood attractions such as parks and recreational facilities, both of which have been linked to lower exercise in adults (Berke et al., 2006; Jauregui et al., 2016; Tucker-Seeley et al., 2009). Moreover, limited opportunities for exercise in disadvantaged neighborhoods may also shape attitudes and norms, which can create further barriers to leading an active lifestyle (Massey, 1996). Overall our study suggests that middle-to-old aged residents of disadvantaged neighborhoods engage in less exercise each week. Future studies are needed to identify specific neighborhood characteristics that may contribute to this association, including different aspects of the social, economic and physical environments.

In contrast, we found that non-exercise physical activity was positively associated with neighborhood socioeconomic deprivation. Most previous investigations of non-exercise physical activity focused on walking for transportation, and lower SES at the individual level has been linked to higher levels of walking for transportation (Berrigan et al., 2006). Similar to our study, previous studies reported that residents of poor neighborhoods were more likely to walk than those living in more affluent places. For example, the percent of households with an income below the poverty line was associated with more walking for transportation in Illinois, independent of individual household income, despite the fact that residents of poor neighborhoods reported more concerns about safety in their neighborhoods (Ross, 2000). It has been postulated that higher population density and greater reliance on public transportation may be responsible for this association. In addition to walking for

transportation, several other activities were also positively associated with neighborhood socioeconomic deprivation in our population, particularly outdoor chores. Few previous studies examined the relationship between neighborhood characteristics and non-exercise physical activity besides walking. In contrast to our finding, Mooney et al. (2017) recently found that indicators of high SES neighborhoods were positively associated with gardening. The discrepancy between this study and ours could be due to the difference in geographic location: the study population in Mooney et al. lived exclusively in the New York City, while our study population resided in six different states and two cities with a much wider range of neighborhoods. It is possible that in different regions of the country, neighborhoods socioeconomic status may be associated with different characteristics of the built, social and economic environment (such as access to gardens), which could have differential effects on physical activity. Moreover, the relationship between neighborhood characteristics and physical activity may differ by individual-level factors. We encourage future studies to investigate in more detail the specific contextual and individual-level factors that may moderate these relationships.

Our findings also suggest that people living in neighborhoods with more severe socioeconomic deprivation are more likely to engage in prolonged sedentary behaviors, particularly watching TV and sedentary transportation (i.e., driving or riding in a bus or train). There have been limited studies on neighborhood characteristics and sedentary behaviors. A recent systematic review identified only four studies that considered the relationship between environmental factors and TV viewing in the older population (Chastin et al., 2015). These studies reported that longer TV viewing was associated with numerous characteristics of the social and physical environment of the neighborhood, including lack of safety, long distance to facilities, low walkability, and lack of cultural facilities and green space (Chastin et al., 2014; Kikuchi et al., 2013; Van Cauwenberg et al., 2014; van der Berg et al., 2014). These factors, particularly longer distances to facilities, may also be responsible for longer sedentary transportation times observed among residents of disadvantaged neighborhoods in our population.

An important strength of our study is its prospective design, which helps establish the temporal relationship of neighborhood exposure and physical activity and sedentary behavior. Moreover, with detailed information on physical activity and sedentary behavior, we were able to conduct separate analysis for different types of activities. In addition, our study included over 17,000 census tracts in six states and two metropolitan areas, which have allowed us examine the relationship between neighborhood SES and physical activity and sedentary behavior in a wide range of geographic areas. Finally, our large sample size allowed us to conduct sensitivity analysis by excluding people who moved out of their neighborhood during the follow up time. The results from the sensitivity analysis and those from the main analysis were almost identical, suggesting that the associations between neighborhood SES and physical activity did not differ for people who moved versus those who remained in their baseline neighborhood. Alternatively, it could be that older adults in this study are less likely to move to neighborhoods with substantially different socioeconomic conditions (Burkhauser et al., 1995).

Our study also has several limitations. First, there are differences in the two questionnaires regarding physical activity and sedentary behavior at baseline and follow up, and only the follow up questionnaire asked about specific types of exercise and non-exercise physical activity. Thus, we were not able to directly assess changes in physical activity and sedentary behavior between the two time points. Moreover, because the information on physical activity and sedentary behavior collected at baseline was less detailed that that collected at follow up, our adjustment of baseline variables may not be sufficient to control for all the impact of baseline level of physical activity and sedentary behavior on our results. Second, information on both physical activity and sedentary behavior was self-reported and subject to error and misclassification. Moreover, the baseline questionnaire asked the participants to recall their activity levels in the last ten years, and long-term recall may be subject to error and recall bias. Third, we had limited individual-level indicators of socioeconomic status, and residual confounding due to other individual characteristics such as household income and occupational status is a concern. In addition, we did not have information on mobility disability, which may constrain people to their immediate environment, and influence the impact of neighborhood conditions on physical activity and sedentary behavior. Fourth, although census information at the tract level has been used by many previous studies as a proxy for “neighborhood”, there has been considerable debate about the appropriate methods to define it in different research contexts (Tatalovich et al., 2006). A substantial body of work in geography and health has emphasized use of activity or experiential space measured via GPS units or by self-report as a potential descriptor of causally relevant environments (Chaix, 2009; Kwan, 2012). However, this approach has not (to our knowledge) been implemented in large cohort studies and would require intense prospective data collection. Alternatively, several researchers have suggested grouping administrative units based on statistical criteria (Spielman and Folch, 2015). This approach could be applied retrospectively in cohort studies and could shed insight into the robustness of results based on census tracts considered separately. Fifth, the participants in the NIH-AARP Diet and Health study are predominantly white and from relatively high socioeconomic status. Therefore, our results may be less generalizable to other populations and neighborhoods. Moreover, only a fraction of the AARP members contacted by mail agreed to enroll in the baseline cohort, and we had to exclude a large proportion of them due to deaths, failure to return questionnaires, and missing information. Sixth, we used 2000 census variables to characterize neighborhood deprivation at baseline (1995–1996), and any changes that occurred in the neighborhood between baseline and 2000 may lead to exposure misclassification. Finally, > 40% of our sample moved between baseline and follow-up, but unfortunately, we do not know the characteristics of their new neighborhoods. Although excluding movers had little impact on our results, we were not able to examine the potential effect of moving to a different neighborhood on physical activity and sedentary behavior.

In conclusion, our findings support a relationship between neighborhood socioeconomic conditions and physical activity and sedentary behavior, but suggest these relationships are nuanced. The high prevalence of prolonged sedentary behavior and low levels of exercise among people in the disadvantaged neighborhoods observed in our study is concerning given the robust relationships for these behaviors and health outcomes (Stewart et al., 2015). However, our study also showed that the level of total physical activity was higher among

people living in more deprived neighborhoods, because lower levels of exercise were offset by higher levels of non-exercise activities. Future studies are needed to confirm if the relationship between neighborhood deprivation and low leisure-time activity may be offset by higher levels of non-exercise physical activity and ultimately how these environmental and individual-level factors related to health. The US Centers for Disease Control Community Preventive Services Task Force recently released a recommendation that environmental approaches combining transportation system interventions with land use and environmental design are recommended to increase physical activity based on existing evidence (Force, 2014). This further supports efforts to explore additional neighborhood and contextual variables. It is noteworthy that many of the neighborhood factors, such as safety and access to facilities, are associated with both sedentary behavior and leisure-time physical activity, and therefore may be good candidates for designing public intervention studies that target disadvantaged neighborhoods to encourage an active lifestyle and improve health in the older population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Baseline study characteristics according to quintiles of deprivation index among 136,526 participants in the National Institutes of Health-AARP Diet and Health Study, 1995–1996.

	Neighborhood socioeconomic deprivation				
	Q1 (high SES)	**Q2**	**Q3**	**Q4**	**Q5 (low SES)**
Age at baseline, mean (SD)	61.7 (5.4)	61.8 (5.3)	62.0 (5.3)	62.3 (5.3)	62.0 (5.3)
Body mass index, kg/m^2, mean (SD)	26.1 (4.4)	26.6 (4.6)	27.0 (4.9)	27.2 (5.1)	27.6 (11.0)
Female, %	36.0	39.0	41.1	43.7	48.8
White, non-Hispanic, %	96.1	95.6	95.8	95.0	85.7
College and postcollege, %	65.0	50.1	40.8	33.3	29.2
Married, %	76.4	72.5	70.5	68.5	61.1
Retired at baseline, %	32.3	35.7	39.0	41.1	38.8
Self-reported health, excellent, %	26.2	21.4	18.4	16.2	14.4
Current smoker, %	6.5	8.2	9.4	10.5	11.9
Nighttime sleep 7–8h/day, %	67.0	64.8	63.6	62.4	58.0
Alcohol consumption, g/day, mean (SD)	14.4 (30.0)	13.4 (32.4)	12.7 (33.6)	12.4 (35.9)	11.0 (36.7)
Fruits and vegetables, servings per 1000 kcal, mean (SD)	4.1 (1.7)	4.0 (1.8)	3.94 (1.77)	3.9 (1.8)	3.9 (1.8)
Whole grains, servings per 1000 kcal, mean (SD)	0.71 (0.45)	0.69 (0.45)	0.69 (0.46)	0.68 (0.46)	0.68 (0.48)
Total fat, % of energy, mean (SD)	0.29 (0.08)	0.30 (0.07)	0.30 (0.08)	0.30 (0.08)	0.31 (0.08)
Red meat, g/1000 kcal, mean (SD)	31.5 (20.6)	33.2 (20.8)	34.4 (21.2)	34.9 (21.3)	34.5 (21.5)
Total energy, kcal/day, mean (SD)	1794 (740)	1823 (814)	1838 (822)	1850 (870)	1888 (962)
Moderate-to-vigorous physical activity, %					
Never or rarely	11.5	12.8	13.3	14.0	16.1
< 1 h/week	9.6	10.6	10.4	10.6	11.4
1–3 h/week	25.7	25.9	25.3	25.8	25.4
4–7 h/week	28.7	27.2	26.5	25.4	24.1
7+ hours/week	24.7	23.6	24.6	24.3	23
TV viewing, %					
< 1 h/day	11.1	7.7	6.1	5.7	5.4
1–2 h/day	35.8	31.7	28.7	26.5	25.8
3–4 h/day	40.7	44.1	45.1	45.9	44.3
5–6 h/day	10.2	13	15.3	16.7	17.7
7+ hours/day	2.2	3.5	4.2	5.2	6.8
Chronic conditions					
Diabetes, %	4.9	5.8	6.9	7.6	8.9
Heart disease, %	10.2	11.1	12.3	12.8	12.8
Stroke, %	1.2	1.2	1.5	1.8	2.3
Cancer, %	10.4	9.7	10.0	10.0	9.2

Abbreviations: SD, standard deviation; SES, socioeconomic status.

Table 2

Prospective association between baseline neighborhood socioeconomic deprivation index and exercise and non-exercise physical activity at follow-up.

	Neighborhood socioeconomic deprivation					*p*-Trend
	Q1 (high SES)	**Q2**	**Q3**	**Q4**	**Q5 (low SES)**	
Exercise, hours/week						
Mean (SD)	5.6 (5.8)	5.1 (5.7)	4.8 (5.7)	4.5 (5.4)	4.0 (5.2)	
β coefficient (95% CI), hour/week						
Base model[a]	Ref	− 0.40 (− 0.50, − 0.30)	− 0.68 (−0.79, −0.58)	−0.92 (−1.02, −0.82)	−1.32 (− 1.42, − 1.23)	< 0.0001
Full model[b]	Ref	− 0.25 (− 0.34, − 0.15)	− 0.42 (−0.52, −0.32)	−0.56 (−0.66, −0.46)	− 0.85 (− 0.95, − 0.75)	< 0.0001
Non-exercise physical activity, hours/week						
Mean (SD)	11.6 (9.5)	12.1 (9.9)	12.9 (10.4)	12.9 (10.4)	13.0 (10.7)	
β coefficient (95% CI), hour/week						
Base model[a]	Ref	0.53 (0.35, 0.70)	0.97 (0.79, 1.14)	1.23 (1.05, 1.41)	1.30 (1.13, 1.48)	< 0.0001
Full model[b]	Ref	0.42 (0.25, 0.59)	0.78 (0.61, 0.96)	0.99 (0.81, 1.17)	1.13 (0.94, 1.32)	< 0.0001

Abbreviations: BMI, body-mass index; CI, confidence interval; MVPA, moderate-to-vigorous physical activity; OR, odds ratio; SD, standard deviation; SES, socioeconomic status.

[a]Adjusted for age (continuous), sex (male, female), and baseline MVPA (never, rarely,<1, 1–3, 4–7, and>7 h per week, for physical activity outcomes).

[b]Adjusted for covariates in footnote a and education (< 12 years, 12 years, post-high school, some college, college/post-graduate, unknown), race (non-Hispanic white, non-Hispanic black, Hispanic, Asian or Pacific islander or American Indian/Alaskan native, other), married (yes, no), retirement status (yes, no), self-reported health (excellent, very good, good, fair, poor), baseline disease history of diabetes (yes, no), heart disease (yes, no), stroke (yes, no) and cancer (yes, no), and state of residence (CA, FL, LA, NJ, NC, PA, GA, MI).

Table 3

Prospective association[a] between baseline neighborhood socioeconomic deprivation index and individual non-exercise physical activity at follow up.

	Neighborhood socioeconomic deprivation					*p*-Trend
	Q1 (high SES)	**Q2**	**Q3**	**Q4**	**Q5 (low SES)**	
Light household chores	Ref	0.03 (−0.02, 0.08)	0.06 (0.01, 0.12)	0.07 (0.02, 0.13)	0.08 (0.02, 0.13)	0.005
Moderate-vigorous household chores	Ref	0.06 (0.03, 0.10)	0.11 (0.07, 0.15)	0.13 (0.09, 0.17)	0.15 (0.11, 0.19)	< 0.0001
Moderate outdoor chores	Ref	0.12 (0.07, 0.17)	0.23 (0.18, 0.28)	0.31 (0.26, 0.36)	0.29 (0.24, 0.34)	< 0.0001
Vigorous outdoor chores	Ref	0.09 (0.06, 0.12)	0.14 (0.11, 0.17)	0.21 (0.17, 0.24)	0.23 (0.19, 0.27)	< 0.0001
Home repairs	Ref	0.05 (0.02, 0.08)	0.09 (0.06, 0.12)	0.10 (0.07, 0.13)	0.14 (0.11, 0.17)	< 0.0001
Caring for children	Ref	0.01 (−0.02, 0.04)	− 0.003 (− 0.03, 0.03)	−0.01 (− 0.02, 0.05)	0.01 (−0.03, 0.04)	0.60
Caring for another adult	Ref	0.02 (−0.01, 0.04)	0.07 (0.05, 0.10)	0.08 (0.05, 0.10)	0.12 (0.09, 0.15)	< 0.0001
Walking for transportation	Ref	0.04 (−0.002, 0.08)	0.08 (0.04, 0.12)	0.08 (0.04, 0.12)	0.12 (0.07, 0.16)	< 0.0001

[a]Associations expressed as β coefficient and 95% CI in parenthesis (unit: hour/week), adjusted for age (continuous), sex (male, female), and baseline MVPA (never, rarely, < 1, 1–3, 4–7, and > 7 h per week, for physical activity outcomes), education (< 12 years, 12 years, post-high school, some college, college/post-graduate, unknown), race (non-Hispanic white, non-Hispanic black, Hispanic, Asian or Pacific islander or American Indian/Alaskan native, other), married (yes, no), retirement status (yes, no), self-reported health (excellent, very good, good, fair, poor), baseline disease history of diabetes (yes, no), heart disease (yes, no), stroke (yes, no) and cancer (yes, no), and state of residence (CA, FL, LA, NJ, NC, PA, GA, MI).

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Table 4

Prospective association between baseline neighborhood socioeconomic deprivation index and sedentary time at follow-up.

	Neighborhood socioeconomic deprivation					*p*-Trend
	Q1 (high SES)	**Q2**	**Q3**	**Q4**	**Q5 (low SES)**	
Watching TV, 5+ hours/day						
No. (%)	4344 (15.9)	5408 (19.8)	6383 (23.4)	6892 (25.2)	7460 (27.3)	
OR (95% CI)						
Base model[a]	Ref	1.13 (1.08, 1.18)	1.29 (1.24, 1.36)	1.34 (1.28, 1.40)	1.42 (1.36, 1.49)	< 0.0001
Full model[b]	Ref	1.07 (1.01, 1.12)	1.18 (1.12, 1.24)	1.19 (1.13, 1.25)	1.21 (1.15, 1.27)	< 0.0001
Driving, 3+ hours/day						
No. (%)	3766 (13.8)	4236 (15.5)	4597 (16.8)	4852 (17.8)	5314 (19.5)	
OR (95% CI)						
Base model[a]	Ref	1.14 (1.09, 1.20)	1.26 (1.20, 1.32)	1.34 (1.28, 1.41)	1.51 (1.44, 1.58)	< 0.0001
Full model[b]	Ref	1.09 (1.03, 1.14)	1.16 (1.11, 1.22)	1.20 (1.14, 1.26)	1.26 (1.20, 1.32)	< 0.0001
Other sitting, 5+ hours/day						
No. (%)	5085 (18.6)	4585 (16.8)	4250 (15.6)	4110 (15.1)	4306 (15.8)	
OR (95% CI)						
Base model[a]	Ref	0.90 (0.86, 0.94)	0.85 (0.81, 0.89)	0.83 (0.79, 0.87)	0.87 (0.83, 0.91)	< 0.0001
Full model[b]	Ref	0.93 (0.89, 0.97)	0.88 (0.84, 0.93)	0.88 (0.84, 0.92)	0.91 (0.87, 0.96)	< 0.0001
Total, 10+ hours/day						
No. (%)	6106 (22.4)	6589 (24.1)	6950 (25.5)	7228 (26.5)	7839 (28.7)	
OR (95% CI)						
Base model[a]	Ref	1.14 (1.09, 1.18)	1.25 (1.20, 1.30)	1.34 (1.29, 1.39)	1.50 (1.44, 1.56)	< 0.0001
Full model[b]	Ref	1.01 (0.97, 1.05)	1.04 (0.99, 1.08)	1.04 (1.00, 1.09)	1.08 (1.04, 1.13)	0.0001

Abbreviations: BMI, body-mass index; CI, confidence interval; OR, odds ratio; SD, standard deviation; SES, socioeconomic status.

[a]Adjusted for age (continuous), sex (male, female), and baseline TV viewing (< 1, 1–2, 3–4, 5–6, 7–8, ≥9 h/day).

[b]Adjusted for covariates in footnote a and education (< 12 years, 12 years, post-high school, some college, college/post-graduate, unknown), race (non-Hispanic white, non-Hispanic black, Hispanic, Asian or Pacific islander or American Indian/Alaskan native, other), married (yes, no), retirement status (yes, no), self-reported health (excellent, very good, good, fair, poor), baseline disease history of diabetes (yes, no), heart disease (yes, no), stroke (yes, no) and cancer (yes, no), and state of residence (CA, FL, LA, NJ, NC, PA, GA, MI).