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Short communication

Neighborhood factors and six-month weight change among overweight individuals in a weight loss intervention

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ABSTRACT

The purpose of this study was to examine the neighborhood environment and the association with weight change among overweight/obese individuals in the first six months of a 12-month weight loss intervention, EMPOWER, from 2011 to 2015. Measures of the neighborhood environment included neighborhood racial composition, neighborhood income, and neighborhood food retail stores density (e.g., grocery stores). Weight was measured at baseline and 6 months and calculated as the percent weight change from baseline to 6 months. The analytic sample (N = 127) was 91% female and 81% white with a mean age of 51 (±10.4) years. At 6 months, the mean weight loss was 8.0 kg (±5.7), which was equivalent to 8.8% (±6%) of baseline weight. Participants living in neighborhoods in which 25–75% of the residents identified as black had the greatest percentage of weight loss compared to those living in neighborhoods with <25% or >75% black residents. No other neighborhood measures were associated with weight loss. Future studies testing individual-level behavioral weight loss interventions need to consider the influence of neighborhood factors, and how neighborhood-level interventions could be enhanced with individual-level interventions that address behaviors and lifestyle changes.

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1. Introduction

For behavioral weight loss interventions to be successful, it is important to understand the various factors that may influence the individual's ability to self-regulate behavior and manage weight control. Behavioral weight loss interventions typically focus on lifestyle behaviors (e.g., eating and physical activity) and psychosocial factors such as self-efficacy, social support and problem-solving skills. While these factors are important, it may also help to consider the larger context or environment, and how it may affect weight change and the adoption of healthful behaviors for the long-term. Observational studies (e.g., cross-sectional), have demonstrated that the neighborhood environment plays an important role in the development of obesity (Auchincloss et al., 2013; Galster, 2012; Glass et al., 2006; Ludwig et al., 2011; Papas et al., 2007). Neighborhood environments may influence lifestyle and body weight through several pathways including the service environment (i.e., grocery stores, amenities), the physical or built environment (i.e., exposure to toxins, access to parks/green space), and the social or economic environment (i.e., income inequality) (Ludwig et al., 2011; Culhane and Elo, 2005). However, it is unclear if the neighborhood environment influences weight change for overweight and obese individuals who are actively attempting to lose weight through organized behavioral interventions.

Few studies have examined the impact of neighborhood factors on the effect of behavioral interventions related to obesity or weight loss. Gustafson et al. (2012) and Wedick et al. (2015) investigated the influence of availability of healthy foods in the neighborhood on the effect of a dietary behavioral intervention focused on changes in diet and eating patterns, potential precursors to weight change. Gustafson et al. (2012) found that healthy food store environments increased fruit and vegetable intake among intervention participants, while Wedick et al. (2015) showed that living closer to stores that carried healthy foods was associated with an increase in consumption of fiber, fruits, and vegetables among obese adults with metabolic syndrome. Another study examined the effect of worksite neighborhood on employees enrolled in a randomized trial to prevent weight gain and found that a higher appraised value of the worksite's neighborhood was associated with increased

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walking among employees (Barrington et al., 2015). Other studies have demonstrated that environmental modification can enhance the success of weight loss interventions, but these studies were specifically among children (Fagg et al., 2014; Best et al., 2012; Epstein et al., 2012). However, none of these prior studies specifically examined the impact of neighborhood factors on weight loss among intervention participants, the focus of the present study.

Given that neighborhood factors are often overlooked in weight loss interventions, the purpose of this study was to examine the neighborhood environment and its association with weight change among overweight and obese individuals in the first six months of a 12-month weight loss intervention study. We hypothesized that individuals living in low-resource neighborhood environments (e.g., low income, absence of grocery stores, high racial segregation) would be less likely to lose weight over time compared to those who live in neighborhoods with more resources and that are health promoting.

2. Methods

2.1. EMPOWER study design and sample

EMPOWER is a longitudinal descriptive study (N = 151) that used ecological momentary assessment (EMA) (Shiffman, 1987; Shiffman, 2000; Burke et al., 2013) to understand participants' behavior in real time in their own environment to determine the triggers for lapses or relapse following intentional weight loss. Inclusion criteria were a body mass index (BMI) >27 and <44 kg/m^2, ≥18 years of age, no recent weight loss and not participating in any other weight loss treatment. All participants received a group-delivered behavioral weight loss intervention over 12 months. Participants set daily goals for energy and fat intake and weekly goals for energy expenditure. They self-monitored their diet and physical activity (PA) using an application (app) on a smartphone and weighed themselves daily on a Wi-Fi scale that was provided by the study. A total of 151 adults were enrolled in the study. For this secondary analysis, we used only baseline to 6-months data. Our final analytic sample (N = 127) including participants with complete data of all key variables. There were no significant differences in demographic factors or BMI comparing the full sample with the analytic sample. The parent study, EMPOWER, and the secondary analysis for this manuscript were both approved by the Institutional Review Board of the University of Pittsburgh.

2.2. Key measures

Weight was measured at baseline and 6 months using the Tanita digital scale. Percent weight change was calculated as weight at six months minus weight at baseline divided by weight at baseline times 100% $[((\text{Weight}_t - \text{Weight}_0) / \text{Weight}_0) \times 100\%]$.

Neighborhood measures were calculated based on the residential address of EMPOWER participants at baseline and were geocoded using ArcGIS software and assigned the appropriate census tract. The neighborhood measures were linked to the EMPOWER individual data based on census tract. Several neighborhood measures were included in this analysis. Grocery store density was measured as the number of stores per census tract divided by the population (per capita) of the census tract. Similarly, restaurant density was measured per capita. There were several census tract level measures derived from the US census and these were categorized into quartiles: income (annual family income < $30,000/year), education (<high school education), households in poverty, and the proportion of black residents. Neighborhood racial composition was operationalized as the proportion black because the tracts in the geographic region are either predominately black or white with limited representation from other racial categories at the neighborhood level. An index of neighborhood socioeconomic disadvantage (NSED) was also created, which is described further below.

2.3. Analytic method for development of NSED index

The measures included in the NSED index were percentages of unemployed individuals, houses with no cars, crowded housing, renters, males not in management and professional occupations, households in poverty, female headed households with dependents, public assistance, earning <$30,000/year, <high school education, black residents, residents under the age of 16. The NSED index was derived using exploratory factor analysis (Tabachnick and Fidell, 2007) based on previous work in the same geographic region and indices used in health research that take into account material deprivation and concentrated disadvantage (Messer et al., 2006; Townsend et al., 1988; Sampson et al., 1997; Mendez et al., 2013). A maximum likelihood extraction method was used, and one factor was extracted with a weighted eigenvalue of 36.1 for the first factor explaining 81% of the total variance of the data.

2.4. Covariates

Several covariates were chosen as potential confounders in the association between neighborhood and weight outcomes based on previous studies (Auchincloss et al., 2013; Gary-Webb et al., 2010). Several demographic self-reported measures were collected at baseline such as age, sex, race/ethnicity (analytic sample only include black, white and Asian participants), relationship status, educational attainment, and household income. We did not include behaviors such as diet and physical activity as confounders, but considered them mediators in the association between neighborhood and weight change. The specific mediators we considered were participants' current smoking status, their baseline scores on the Barriers to Healthy Eating Scale (Fowles and Feucht, 2004), and at baseline the number of times per week over the past three months they engaged in excessive exercise.

2.5. Statistical analysis

SAS version 9.4 (Cary, NC) was used for analysis. We excluded 15 participants who lived outside of the study area or that did not have a complete residential address, and 9 who had missing weight data at 6 months for an analytic sample of 127 participants with complete data. Descriptive analyses were conducted for the key variables of interest. Analysis of variance (ANOVA) was conducted to test differences in the mean percentage weight change across the various individual-level and neighborhood-level factors. In this sample, there was on average 1 person per census tract (range of 1–5 people per tract), and thus our modeling strategy was a fixed effects model rather than treating individuals nested within neighborhoods in a hierarchical or multilevel model. In the unadjusted models, neighborhood proportion of black was the only factor associated with weight change based on an a priori p-value of <0.05. As a result, subsequent analyses focused on this association. Before conducting a generalized linear model, we examined neighborhood values for neighborhood proportion of black that could be considered outliers or implausible. There were no outliers for this exposure of interest. Based on the unadjusted association between the individual-level factors and percentage weight change, the final models were adjusted for sex, race, and years of formal education. We did not adjust for any other neighborhood variables since they were not associated with the outcome of interest. We conducted a sub-analysis of the racial differences in percentage weight change among participants living in neighborhoods with the lowest proportion black. We did not include potential mediators since there was no association between each of the specific mediators and percentage weight change among this population.

3. Results

The EMPOWR analytic sample (N = 127) is 91% female, 81% white, a mean (SD) of 16.6 (±2.8) years of formal education (72% with bachelor's degree or higher, results not shown), and a mean (SD) age of 51.2 years (±10.2). At 6 months, the mean (SD) weight loss for the sample was 17.7 lb (±12.6) which is equivalent to a loss of 8.8% (±6%) of baseline weight (Table 1). The majority of participants lived in neighborhoods (i.e., census tracts) with residents who were predominately white (lowest proportion black, 0–25%) (N = 110, 87%), had a middle to high level of education (N = 127, 100%), and low poverty (N = 121, 95%) with a mean grocery store density of 6 per 10,000 residents and restaurant density of 20.6 per 10,000 residents. Among EMPOWER participants living in neighborhoods with the lowest proportion black residents (0–25%) (N = 110), 95 of the EMPOWER participants were white, 12 were black, and 3 Asian; within the neighborhoods with the highest proportion black, 1 white and 3 black EMPOWER participants lived in these neighborhoods. The remaining (7 white and 6 black) lived in neighborhoods that were 25–75% black. In essence, 92% of the EMPOWER participants who were white lived in neighborhoods with the lowest proportion of black residents (0–25%) while almost 60% of the participants who were black lived in these same neighborhoods (results not shown). In the unadjusted association, weight change was not associated with grocery store or restaurant density, or neighborhood education or income levels (Table 2). However, the proportion of black residents in the neighborhood was associated with weight change; those who lived in racially mixed neighborhoods (25–75% black, n = 13) were more likely to lose weight (weight loss of 11.8%, SD: 5.2) compared to those who lived in more segregated neighborhoods (0–<25% black [predominately white], n = 110; weight loss of 8.7%, SD:3.1 and >75% black [predominately black], n = 4 weight loss of 2.4%, SD: 6.5). In the sub-analyses of the racial difference in percentage weight change among those living in neighborhoods characterized as 0–<25% black, the mean percentage weight change among whites was −9.1 (SD: 5.9), −4.6 (SD: 5.0) among blacks and −10.5 (SD: 2.4) among Asians ($p < 0.05$) (results not shown). Neighborhoods characterized as 0–<25% and 25–50% black had the highest density of grocery stores and restaurants compared to neighborhoods that were >50% black, and neighborhoods that were 0–25% black had the highest income compared to other neighborhoods (results not shown). In fully adjusted models, participants living in neighborhoods that with 25–75% black residents still had the greatest percentage of weight loss compared to those living in neighborhoods with <25% or >75% black residents although weight loss occurred in all neighborhood types ($p < 0.001$) (results not shown).

Table 1
Individual characteristics and unadjusted association with percent weight change at 6 months (N = 127)[a].

Individual characteristics	M (SD) or N %	Percent weight change: *r* or M (SD)	p-Value
Sex (female) (N, %)	115 (90.6)	−8.4 (5.8)	0.02*
Male	12 (9.4)	−12.5 (6.8)	
Race (N, %)			0.015*
White	103 (81.1)	−9.4 (5.9)	
Black	21 (16.5)	−5.4 (5.8)	
Asian	3 (2.4)	−10.5 (2.4)	
Age (M, SD)	51.3 (10.2)	0.018	0.84
Years of formal education (M, SD)	16.6 (2.8)	−0.19	0.04*
Marital status (N, %)			
Never married	23 (18.3)	−9.7 (6.6)	0.22
Married/living with significant other	77 (61.1)	−9.1 (5.5)	
Widowed/separated/divorced	26 (20.6)	−7.0 (6.8)	
(Missing)	1		
Household income (total gross annual) (N, %)			0.14
<$30,000	7 (5.5)	−4.8 (4.5)	
$30,000 to <$60,000	31 (26.1)	−8.4 (6.6)	
$60,000 to <$100,000	37 (31.1)	−10.1 (5.5)	
Over $100,000	44 (37.0)	−8.2 (5.8)	
(Unknown/missing)	8		
Current smoker (yes)	2 (1.6)	−6.7 (4.3)	0.25
No	125 (98.4)	−8.8 (6.0)	
Barrier to health eating score (total) (M, SD)	57.8 (13.7)	−0.013	0.9
Excessive exercise (times per week) (N, %)			0.23
0	121 (95.3)	−8.9 (6.0)	
1 or more	6 (4.7)	−5.9 (5.7)	
Baseline weight (lbs) (M, SD)	201.8 (32.7)	–	
Six-month weight (lbs) (M, SD)	185.0 (32.7)	–	
Percentage weight change	−8.8% (6%)	–	

[a] EMPOWER Study, Pennsylvania, 2011–2015.
* $p < 0.05$.

Table 2
Neighborhood characteristics and unadjusted association with percent weight change at 6 months (N = 127).[a]

Neighborhood measures	N (%)	Percent weight change: M (SD)	p-Value
Grocery store/supermarket density[b]			0.3454
0	28 (20.6)	−9.95 (6.49)	
1–5	36 (29.4)	−7.74 (5.20)	
6+	63 (50.0)	−8.87 (6.21)	
Restaurant density[b]			0.4344
0	5 (3.9)	−5.65 (1.39)	
1–12	56 (44.1)	−8.62 (5.60)	
13+	66 (52.0)	−9.18 (6.51)	
Proportion black			0.0183*
0–<25%	110 (86.6)	−8.66 (5.91)	
25–<75%	13 (10.2)	−11.84 (5.26)	
75%+	4 (3.2)	−2.42 (6.63)	
Low education			0.8925
0–<25%	121 (95.3)	−8.81 (5.83)	
25–<50%	6 (4.7)	−8.46 (9.75)	
50–<75%	0	N/A	
75%+	0	N/A	
Low income			0.5964
0–<25%	28 (22.1)	−8.32 (5.24)	
25–<50%	72 (56.7)	−9.26 (6.1)	
50–<75%	27 (21.3)	−8.03 (6.5)	
75%+	0	N/A	
Household poverty			0.4174
0–<25%	121 (95.3)	−8.89 (6.11)	
25–<50%	6 (4.7)	−6.84 (V)	
50–<75%	0	N/A	
75%+	0	N/A	
Neighborhood SED index			0.0832
Low [0–<14.8]	32 (25.2)	−8.43 (5.50)	
Mid-low [14.8–<18.5]	32 (25.2)	−7.74 (5.27)	
Mid-high [18.5–<24.2]	30 (23.6)	−11.22 (5.87)	
High [24.2+]	33 (26.0)	−7.95 (6.88)	

N/A indicates there were no participants in this group (n = 0)
[a] EMPOWER Study, Pennsylvania, 2011–2015.
[b] Per 10,000 residents in census tract. Food Environment variables included data from Dun and Bradstreet and InfoUSA/Group for Allegheny County, PA in 2009.
* $p < 0.05$.

4. Discussion

We found that EMPOWER participants living in neighborhoods with 25–75% black residents had the greatest weight loss compared to participants living in other neighborhoods. Our findings, in the context of a behavioral weight loss intervention, suggest that individuals living in racially diverse neighborhoods may be more likely to lose weight, even after adjustment for individual characteristics, compared to individuals living in predominately white or predominantly black neighborhoods. We also found racial differences in percentage weight loss with Asians, followed by whites and then blacks having the greatest loss. Although this study did not specifically examine all possible indicators of residential segregation, segregation is theorized to be a major determinant of racial disparities in health and a contributor to obesity due to obesogenic environments produced by racial and socioeconomic segregation (Massey and Denton, 1988; Williams and Collins, 2001). Prior studies investigating the influence of segregation on obesity are mixed showing varying results based on the racial composition of the study population (Chang, 2006; Kershaw et al., 2013) or by sex (Chang et al., 2009). Among the neighborhoods represented in this study, the racially diverse neighborhoods had variability in income and were more likely to have restaurants and grocery stores. This commercial activity may also be indicative of the economic well-being of the neighborhoods overall or an indication of neighborhood transition. However, in this study, we did not specifically measure neighborhood change. No other neighborhood factors were associated with weight change in this study. This was contrary to our hypothesis but not completely surprising given the heterogeneity in methods and results in prior studies investigating the built environment and obesity (Feng et al., 2010).

Few studies have specifically investigated the effects of neighborhoods in the context of behavioral interventions and have measured changes in diet but not specifically changes in weight. One study found that living close to stores providing healthy foods improves consumption of fiber (Wedick et al., 2015) and another study found that among people living in neighborhoods with low supermarket density, those participating in a behavioral intervention versus controls were more likely to consume fruits and vegetables (Gustafson et al., 2012). These studies suggest that the neighborhood environment may play an important role, particularly when paired with individual-level interventions. Along this pathway from neighborhood environment to weight change, this study examined important lifestyle factors as mediators. Although the specific measurements of smoking, eating, and exercise included in the study were not associated with weight loss, the overall constructs related to these measurements have been related to weight in general in prior studies. Perhaps the ways in which these constructs were measured are important and similar measurements could be associated with weight but vary for weight loss. Finally, there may be other unmeasured mediators that could potentially explain the pathway from an upstream factor such as neighborhood context and outcomes such as weight loss. To our knowledge, our study is the first to demonstrate the independent influence of neighborhood factors, specifically neighborhood racial composition, on a person's response to a behavioral intervention for weight loss; although it is not clear all of the potential pathways from neighborhood environments to weight change among this particular population.

There were several limitations to this study. First, this study did not include a control arm to compare the effect of the intervention and the neighborhood environment as a potential modifier in the association with weight change. However, we were able to examine whether residence in certain types of neighborhoods influenced weight change for individuals attempting to lost weight. Second, due to the sample size, some neighborhood types had a significantly smaller sample; for example, in this sample, only 4 participants lived in neighborhoods with >75% black residents compared with the 110 participants living in neighborhoods with <25% black residents. Third, we used existing data sources to capture the neighborhood environment, which has limitations in terms of capturing other aspects of the neighborhood. For the food environment data, the study team combined several existing data sources to capture the most complete picture of the food environment and minimize potential issues with missing data (Mendez et al., 2014). Finally, this study used the census tract as a proxy for the neighborhood, and the census tract assigned to a respondent may not completely capture his or her residential environment or the key neighborhoods he/she interacts with. Despite these limitations, to the best of our knowledge, this is the first study that investigated the influence of several neighborhood factors as important in understanding weight loss among overweight individuals participating in a behavioral weight loss intervention. Future studies should consider this phenomenon among larger samples in order to confirm the results found in the present study.

5. Conclusion

The findings of our study indicate that neighborhoods, particularly neighborhood racial composition, may be important for understanding weight loss. Future weight loss interventions need to consider neighborhood factors to better understand how to improve weight loss for all population groups. This study should be replicated in a larger cohort with representation of individuals from various neighborhoods and a more diverse sample.

Conflict of interest

The authors declare there is no conflict of interest.

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References

Auchincloss, A.H., et al., 2013. Neighborhood health-promoting resources and obesity risk (the multi-ethnic study of atherosclerosis). Obesity (Silver Spring) 21 (3), 621–628.
Barrington, W.E., et al., 2015. Worksite neighborhood and obesogenic behaviors: findings among employees in the Promoting Activity and Changes in Eating (PACE) trial. Am. J. Prev. Med. 48 (1), 31–41.
Best, J.R., et al., 2012. Behavioral economic predictors of overweight children's weight loss. J. Consult. Clin. Psychol. 80 (6), 1086–1096.
Burke, L.E., et al., 2013. EMA adherence among adults seeking weight loss treatment. Society for Behavioral Medicine (Annals of Behavioral Medicine).
Chang, V.W., 2006. Racial residential segregation and weight status among US adults. Soc. Sci. Med. 63 (5), 1289–1303.
Chang, V.W., Hillier, A.E., Mehta, N.K., 2009. Neighborhood racial isolation, disorder and obesity. Soc. Forces 87 (4), 2063–2092.
Culhane, J.F., Elo, I.T., 2005. Neighborhood context and reproductive health. Am. J. Obstet. Gynecol. 192 (5 Suppl), S22–S29.
Epstein, L.H., et al., 2012. The built environment moderates effects of family-based childhood obesity treatment over 2 years. Ann. Behav. Med. 44 (2), 248–258.
Fagg, J., et al., 2014. From trial to population: a study of a family-based community intervention for childhood overweight implemented at scale. Int. J. Obes. 38 (10), 1343–1349.
Feng, J., et al., 2010. The built environment and obesity: a systematic review of the epidemiologic evidence. Health Place 16 (2), 175–190.
Fowles, E.R., Feucht, J., 2004. Testing the barriers to healthy eating scale. West. J. Nurs. Res. 26 (4), 429–443.
Galster, G.C., 2012. The mechanism(s) of neighborhood effects: theory, evidence, and policy implications. In: van Ham, M., et al. (Eds.), Neighborhood Effects Research: New Perspectives. Springer, London.
Gary-Webb, T.L., et al., 2010. Neighborhood and weight-related health behaviors in the Look AHEAD (Action for Health in Diabetes) study. BMC Public Health 10, 312.
Glass, T.A., Rasmussen, M.D., Schwartz, B.S., 2006. Neighborhoods and obesity in older adults: the Baltimore memory study. Am. J. Prev. Med. 31 (6), 455–463.
Gustafson, A.A., et al., 2012. Food store environment modifies intervention effect on fruit and vegetable intake among low-income women in North Carolina. J. Nutr. Metab. 2012, 932653.
Kershaw, K.N., Albrecht, S.S., Carnethon, M.R., 2013. Racial and ethnic residential segregation, the neighborhood socioeconomic environment, and obesity among Blacks and Mexican Americans. Am. J. Epidemiol. 177 (4), 299–309.
Ludwig, J., et al., 2011. Neighborhoods, obesity, and diabetes—a randomized social experiment. N. Engl. J. Med. 365 (16), 1509–1519.
Massey, D., Denton, N., 1988. The dimensions of residential segregation. Soc. Forces 67 (2), 281–315.
Mendez, D.D., et al., 2013. Neighborhood socioeconomic disadvantage and gestational weight gain and loss. Matern. Child Health J.
Mendez, D.D., et al., 2014. A methodology for combining multiple commercial data sources to improve measurement of the food and alcohol environment: applications of geographical information systems. Geospat. Health 9 (1), 71–96.
Messer, L.C., et al., 2006. The development of a standardized neighborhood deprivation index. J. Urban Health 83 (6), 1041–1062.
Papas, M.A., et al., 2007. The built environment and obesity. Epidemiol. Rev. 29, 129–143.
Sampson, R.J., Raudenbush, S.W., Earls, F., 1997. Neighborhoods and violent crime: a multilevel study of collective efficacy. Science 277 (5328), 918–924.

Shiffman, S., 1987. Maintenance and relapse. In: Nirenberg, T.D., Maisto, S. (Eds.), Developments in the Assessment and Treatment of Addictive Behaviors. Ablex Press, Norwood, NJ, pp. 353–385.
Shiffman, S., 2000. Real-time self-report of momentary states in the natural environment: computerized ecological momentary assessment. In: Stone, A.A., Jobe, J., Bachrach, C., Kurtzman, H., Cain, V. (Eds.), The Science of Self Report: Implication for Research and Practice. Erlbaun, Mahwah NJ, pp. 277–296 (J.T. In).
Tabachnick, B.G., Fidell, L.S., 2007. Using Multivariate Statistics. 5th ed. Allyn and Bacon, Boston, MA.
Townsend, P., Phillimore, P., Beattie, A., 1988. Health and Deprivation: Inequality and the North. Croom Helm, London; New York.
Wedick, N.M., et al., 2015. Access to healthy food stores modifies effect of a dietary intervention. Am. J. Prev. Med. 48 (3), 309–317.
Williams, D.R., Collins, C., 2001. Racial residential segregation: a fundamental cause of racial disparities in health. Public Health Rep. 116 (5), 404–416.