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Examining the association between intervention-related changes in diet, physical activity, and weight as moderated by the food and physical activity environments among rural, Southern adults

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Abstract

Background—Few studies have been conducted in rural areas assessing the influence of community-level environmental factors on residents' success improving lifestyle behaviors.

Objective—To examine whether 6-month changes in diet, physical activity, and weight were moderated by the food and physical activity environment in a rural adult population receiving an intervention designed to improve diet and physical activity.

Design—We examined associations between self-reported and objectively-measured changes in diet, physical activity, and weight, and perceived and objectively-measured food and physical activity environments. Participants were followed for 6 months.

Participants/Setting—Participants were enrolled in the Heart Healthy Lenoir (HHL) Project, a lifestyle intervention study conducted in Lenoir County, located in rural southeastern NC. Sample sizes ranged from 132 to 249, depending upon the availability of the data.

Intervention—Participants received 4 counseling sessions that focused on healthy eating (adapted Mediterranean diet pattern) and increasing physical activity.

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Potential moderating factors—Density of and distance to food and physical activity venues, modified food environment index, Walk Score®, crime, and perceived nutrition and physical activity neighborhood barriers.

Outcome Measures—Diet quality, physical activity, and weight loss.

Statistical Analyses—Correlation and linear regression, controlling for potential confounders (baseline values of the dependent variables, age, race, education, and sex).

Results—In adjusted analysis, there was an inverse association between weight change and the food environment, suggesting that participants who lived in a less healthy food environment lost more weight over the 6-month intervention period ($P = 0.01$). Also, there was a positive association between self-reported physical activity and distance to private gyms ($P = 0.04$) and an inverse association between private gym density and pedometer-measured steps ($P = 0.03$), indicating that those who lived further from gyms and in areas with lower density of gyms had greater increases in physical activity and steps, respectively.

Conclusions—Contrary to our hypotheses, results indicated that those living in less favorable food and physical activity environments had greater improvements in diet, PA and weight, compared to those living in more favorable environments. Additional research should be undertaken to address these paradoxical findings, and if confirmed, to better understand them.

Keywords

diet; physical activity; food environment; built environment; lifestyle intervention

INTRODUCTION

Community-level factors may hinder or facilitate adult residents' attempts to consume a healthful diet and be physically active.[1] For example, there are inverse associations between access to supermarkets and farmers' markets and obesity;[2] and between access to recreational facilities and obesity.[3] Recent review articles have found that supermarket availability was generally inversely related to obesity, and fast food availability was generally positively associated with obesity.[4, 5] In the rural environment, distance to recreation facilities, feeling unsafe from crime, and few non-residential destinations were associated with obesity.[6] In addition, built environmental characteristics, such as access to places to be active and neighborhood walkability are associated with physical activity (PA) and obesity.[7] Furthermore, residents of neighborhoods that have higher Walk Score®, (a measure of neighborhood amenity density) tend to walk more compared to those with lower Walk Score®.[8, 9]

These associations between the food and PA environment and diet and PA-related activities and outcomes have led to the hypothesis that environmental context might moderate the effect of diet and PA-related intervention outcomes. Two studies have examined the hypothesis that dietary behavior change interventions may be more effective when participants live in areas where more healthful foods are available[10, 11] with the potential causal mechanism being that individuals who live in areas with more healthy eating opportunities are more likely to increase healthy eating behaviors. Both studies found greater adherence to dietary interventions among those with improved access to healthy food sources such as supermarkets, farmers' markets, and green carts. [10, 11] Four additional studies have examined factors in the perceived and objectively-assessed built environment related to PA, generally finding improvements in PA among those participants who lived in more favorable PA environments.[12–15] However, both the diet- and PA-focused studies[10–15] were set primarily in urban areas, further supporting the need to determine whether the food and PA environment may moderate the effect of diet and PA interventions among rural residents.

Therefore, in the Heart Healthy Lenoir (HHL) Project lifestyle study, we compared changes in diet, PA, and weight loss (at 6-months) among lifestyle intervention participants who resided in healthier food and PA environments to those who resided in less healthy environments. We hypothesized that those who lived closer to supermarkets and farmers' markets, and further from fast food restaurants and convenience stores, would have greater intervention-related increases in fruit and vegetable consumption and greater improvements in overall diet quality over the intervention period, compared to those living in less healthy food environments. We also hypothesized that those who lived closer to PA resources (e.g., parks, gyms), and in more walkable, low-crime areas would have greater intervention-related increases in total PA and walking (as assessed by steps) over the intervention period, when compared to those living in neighborhoods less conducive to PA. Our study is unique from others in that our study 1) was set in a rural environment in the Southern United States, whereas others were set in urban areas; 2) examined both perceived- and objectively-measured aspects of the food and PA environments; and 3) included both self-reported and objectively measured outcome data on intervention-related dietary and PA changes.

MATERIALS AND METHODS

Study setting and participants

We used baseline and six-month follow-up data from the HHL lifestyle study, which enrolled residents primarily from Lenoir County, located in rural eastern NC.[16] The HHL lifestyle intervention study, one of three coordinated studies (lifestyle, high blood pressure, and genomics) was conducted as part of the overall HHL Project, a collaborative research effort designed to reduce CVD risk and disparities in risk in Lenoir County, as previously described.[16, 17] The study was approved by the [Blinded for Review] Institutional Review Board, with data collection beginning on September 20, 2011, and six-month data collection completed on April 27, 2012. Research staff screened potential participants (primarily by phone) to determine if they met eligibility criteria, as described previously.[16] If the participant met eligibility criteria, he/she was invited to an enrollment visit where written informed consent was first obtained, and then study-related questions were answered.[16]

In total, of 339 participants enrolled in the HHL Lifestyle Study, 291 took part in the lifestyle intervention given during the first 6 months of the study. Of the 339 originally enrolled, 48 did not attend the 6-month follow-up visit, 40 withdrew, and 2 were excluded from analyses (1 diagnosed with cancer, one withdrew), leaving 249 of the 339 for 6-month analysis. Compared on baseline characteristics, those who did not return for follow-up measures were more likely to be male, white, younger, and of lower educational status. [16]

Lifestyle Study intervention

The lifestyle study was comprised of 3 phases. During Phase 1, the focus of this paper, the lifestyle intervention was given during 4 counseling sessions at monthly intervals with outcomes assessed at 6-month follow-up as previously described in detail in a prior publication. [16] The intervention content was culturally appropriate to the Southern diet and the lifestyle recommendations were individually-tailored to participants' baseline lifestyle behaviors, as previously assessed in randomized trials.[18–21] However, in this study, the dietary content was modified to include a major focus on improving dietary fat as well as carbohydrate quality.[22, 23] The dietary recommendations were very similar to those advocated in the PREDIMED randomized trial intervention study;[16, 23–25] hence, the dietary intervention was called Med-South. (The Med-South dietary intervention materials can be found on the HHL Project website at: http://www.hearthealthylenoir.com/lifestyle-intervention-materials.) Diet counseling comprised about three-fourths of intervention content and time; the remainder was devoted to PA counseling, with a goal of walking ≥ 7,500 steps/day or ≥ 30 minutes on at least 5 days/week. Participants also received an illustrated guide listing local community resources for healthy eating and PA (e.g., farmers' markets and local parks). The Phase I lifestyle intervention did not specifically focus on weight loss.

Basis for examining potential environmental moderators

In order to examine the potential for environmental moderators of intervention effectiveness, evidence of an intervention effect is required. The HHL Lifestyle Study intervention had positive effects on diet, physical activity and weight loss at 6-month follow-up, as previously reported.[16] There was an improvement in overall dietary pattern as assessed by the Dietary Risk Assessment (DRA), a validated brief food frequency questionnaire.[26, 27] The total DRA score increased (improved) by 4.3 units (95% CI 3.7 to 5.0). [16] Similarly, there was an increase in physical activity as assessed by the modified RESIDE questionnaire[28, 29] of 97 minutes per week (95% CI 36 to 158). [16] In addition, there was slight but significant weight loss of −0.7 kg (95% CI −1.2 to −0.3) at 6-month follow-up. [16] These findings suggesting intervention effectiveness were the basis for examination of moderation by the food and PA environments.

Overview of potential moderators: Measures of the food and PA environments

We examined elements of the food and PA environments that have been related to diet, PA, and obesity in previous studies,[2, 4, 5, 7, 8] as potential moderators, including: Geographic Information System (GIS)-measured proximity to supermarkets, farmers' markets, convenience stores, fast food restaurants, gyms, and parks and trails; the modified Food Retail Environment Index (mRFEI);[30] perceived nutrition and PA neighborhood barriers; Walk Score®; and objectively-measured crime rates, each described in detail below.

Objectively-assessed food environment measures

HHL lifestyle intervention participants' residential addresses were geocoded in a GIS. A 1-mile street-network buffer was drawn around each participant's residential address using ArcGIS Network Analyst-Service Area Analysis (ESRI, Redlands, California). Address data for fast food restaurants, supermarkets, farmers' markets, convenience/corner stores, parks, trails, and gyms was obtained using six structured community audits, described elsewhere.[17] Several food environment measures were examined: 1) The *density*, (number) of fast food restaurants, supermarkets, farmers' markets, and convenience/corner stores within each participant's 1-mile GIS buffer, and 2) the closest *distance* to each venue from each participant's residential address. A 1-mile GIS buffer is commonly used in food environment research, and is thought to encompass an area that is feasible to walk and drive to when purchasing food.[31] We also examined the mRFEI, which is the number of supercenters, supermarkets, and farmers' markets, divided by the number of all food venues (supercenters, supermarkets, farmers' markets, fast food restaurants, and convenience stores) in participants' census tracts. A higher mRFEI indicates a healthier food environment (e.g., more supercenters, farmers' markets, and supermarkets and fewer fast food restaurants and convenience stores in a resident's 1-mile buffer).[30]

Objectively-assessed PA environment variables

It was hypothesized that neighborhood amenity density would be associated with PA and more walking. Thus, Walk Score® was obtained by manually inputting participants' residential addresses into the Walk Score®, website (https://www.walkscore.com, accessed May 2015) and the resulting Walk Score®, was used as an independent variable.[32] Because crime is thought to influence PA,[33] Kinston crime rates were obtained from www.crimereports.com. The website only included crime rates for Kinston (county seat) and not the surrounding areas of Lenoir County. The Crime Report was measured from 11/13/2014-12/13/2014, and included a sum score that encompassed homicide, breaking and entering, robbery, theft, theft of/from vehicle, vehicle recovery, sexual offense, and assault. Data included on the Crime Reports website are sent during regular intervals (hourly, daily, or weekly) from more than 1000 participating agencies to the CrimeReports map. Each agency decides upon when to send data.[34] Because crime rates were only obtained for those living in Kinston, the analyses related to crime include only the HHL participants that lived in Kinston. GIS- measured density of (using a 1-mile buffer)[35] and distance to closest PA venues (parks and trails, and gyms [private and low-cost]) were calculated as described above for the objectively-measured food environment variables.

Perceived food and PA environment measures

Participants used a Likert scale to indicate the magnitude of six possible nutrition-related neighborhood barriers (1 = not a problem, 5 = a very big problem). Barriers included too many fast food places; not enough food stores with affordable fruits and vegetables; not enough restaurants with healthy food choices; not enough farmer's markets or produce stands; no place to buy a quick, healthy meal to go; rural environment. These were summed to create a perceived nutrition barriers score, ranging from 6 – 30, with a higher number indicating more perceived nutrition barriers in the neighborhood.

Similarly, participants also used the same 5-point Likert scale to indicate the magnitude of 13 possible PA-related neighborhood barriers. PA-related barriers included not enough sidewalks; not enough bike lanes; not enough parks, trails, or tracks for walking; not enough affordable exercise places; not enough PA programs that met individuals' needs (e.g.

through the Parks and Recreation Department); high crime; no street lights; unattended dogs; heavy traffic; bad air from cars or factories; verbal abuse from people on the street; speeding drivers; rural environment. These were summed to create a perceived PA barriers score, ranging from 13 to 65, with a higher number indicating greater perceived PA barriers. Both of these scales have been used in prior research among low-income populations.[36, 37]

Outcome measures

Lifestyle outcomes were assessed at baseline and 6-month follow-up. The DRA, a previously validated brief food frequency questionnaire,[26,27] was used to assess overall diet quality. As this instrument was administered at the first counseling session (not at the baseline assessment visit) the number of participants that completed the DRA is less than for other baseline measures. The DRA is a food frequency questionnaire that includes frequencies for food and beverage items with 4 sub-scales that address the usual consumption of 1) nuts, oils, dressings, and spreads, 2) vegetables, fruits, whole grains, and beans, 3) drinks, desserts, snacks, eating out, and salt, and 4) fish, meat, poultry, dairy, and eggs. The DRA has been shown to be a valid indicator of diet quality in a variety of Southern populations.[26, 27] Fruit and vegetable consumption was also assessed by assay of blood carotenoids (Molecular Epidemiology and Biomarker Research Laboratory, University of Minnesota, Minneapolis, MN) as previously described.[27] A carotenoid index was calculated as the sum of α-carotene, β-carotene, β-cryptoxanthin, and zeaxanthin, with a higher index indicating greater fruit and vegetable consumption.

Self-reported total PA was the sum of all PA recorded on the modified and previously validated RESIDE questionnaire,[28, 29] which included responses for: walking for transportation, walking for recreation, vigorous leisure time PA, and moderate leisure time PA. To assess steps/day, at the enrollment visit (prior to the intervention) participants were instructed to wear an Omron HJ-720ITC pedometer (Omron Healthcare, Bannockburn, IL) for at least 1 week during the next month, though they were encouraged to wear it daily. Pedometer steps were downloaded at the first counseling session, about one month after the enrollment visit, and at the 6 month follow-up visit. Steps/day were averaged for all days of at least 500 daily steps during the preceding 31 days. At least 3 days meeting this minimum was required for inclusion in analyses. Participants who are elderly and/or living with a chronic illness may regularly take < 1000 steps/ day.[38] Thus, the pedometer cut-point of 500 steps per day (equivalent to approximately 0.25 miles) seemed like a reasonable estimate to eliminate artifact.[39] Weight, the average of two measures to the nearest tenth of a pound, was measured by electronic scale (Seca 874, Seca, Hanover, MD) with the participant in light clothing and without shoes. Height, obtained only at baseline, was measured using a portable stadiometer (Weigh and Measure, LLC, Olney, MD) while the participant, without shoes, stood with their back aligned to the instrument.

Statistical analysis

We examined associations between the magnitude of change (from baseline to six-months) in diet, blood carotenoids, PA, and weight (hereafter called change variables) and food and PA environment variables in order to assess moderation. Descriptive statistics were used to characterize participants at baseline. We used Pearson correlation coefficients to examine associations between change variables and all objectively-assessed and perceived food and PA environment variables. We considered correlations between 0.1 and 0.3 as low, 0.3 and 0.5 as moderate, and over 0.5 as a strong correlation.[40] Linear regression models were used to examine associations between the change variables and food and PA environments in order to assess moderation. The primary dependent variables were 6-month pre/post intervention change in 1) DRA score, 2) carotenoid index, 3) total self-reported PA time (minutes/week), 4) pedometer measured steps/day, and 5) weight. Independent variables were the objectively-assessed food and PA environment variables and perceived environment variables as outlined above. In all models, we controlled for the baseline values of the dependent variables and also for potential confounders including age (continuous in years), race (black or white), education (highest grade completed), and sex. If the parameter estimate for the food and PA environments was significant, we considered the environmental variable a potential moderator. SAS version 9.3 (SAS Institute, Cary, North Carolina) was used for all analyses.

RESULTS

Table 1 shows baseline participant characteristics for those who returned for 6-month measures. The mean age of participants was 56.5 years, mean BMI was 36.3 kg/m^2, mean self-reported PA was 160.2 minutes per week, and mean steps/ day (as assessed by pedometer) was 4525. In addition, 80% were female, and 68% were African American. Only participants who also provided a valid physical address for geocoding were included in analyses including GIS measures (n = 191), and only participants residing in Kinston were included in analyses for crime data (n = 132). Those with valid address data self-reported more PA ($P = 0.01$), were more likely to report crime as a neighborhood barrier ($P = 0.01$), had higher Walk Score®, ($P = 0.002$), lower BMI ($P = 0.04$) and more steps as assessed by pedometer ($P = 0.03$). Those with crime data were younger ($P = 0.02$), self-reported more PA ($P = 0.02$), had higher diet quality as assessed by the DRA ($P = 0.01$), reported too many fast food restaurants and too much crime as neighborhood barriers ($P = 0.04$, $P = 0.02$; respectively), and had higher Walk Score® ($P = 0.0002$), compared to those without crime data.

Table 2 reports bivariate associations between food environment variables and diet-related outcomes at 6-month follow-up. There was a low, statistically significant correlation between greater supermarket density and greater improvements in the carotenoid index. There was a low, statistically significant correlation between higher mRFEI scores and weight change, indicating greater weight loss among those living in less healthy food environments. There was a positive correlation between six-month change in diet as assessed by the DRA and perceived nutrition barriers: those who perceived more nutrition-related neighborhood barriers had greater improvements in diet than did those who perceived fewer barriers.

Table 3 reports bivariate associations between PA environment variables and PA-related outcomes at 6-month follow-up, with two low, statistically significant negative correlations. The inverse associations between 1) density of private gyms and pedometer-measured steps/day indicate those living in areas with more gyms had lower increases in steps/day compared to those living in areas with fewer gyms and 2) crime and weight change indicate greater weight loss among those living in higher objectively-measured crime neighborhoods.

In Table 4, we present parameter estimates, standard errors, and *P*-values for multiple linear regression analyses for the six bivariate associations with a *P*-value < 0.10. In adjusted analyses, there was an inverse association between weight change and mRFEI, suggesting that participants who lived in a less healthy food environment lost more weight ($P = 0.01$). In addition, contrary to our initial hypotheses, there was a positive association between self-reported total PA change and distance to private gyms, such that those who lived further from private gyms reported greater increases in total PA from baseline to six-months ($P = 0.04$), and an inverse association between pedometer measured steps/day and density of private gyms, such that those living in areas with greater density of gyms had lower increases in the number of daily steps from baseline to six months ($P = 0.03$).

DISCUSSION

In this study, we examined the potential for moderation of intervention effects by comparing diet and PA outcomes among participants residing in healthier food and PA environments to those residing in less healthy environments. In correlational analyses, we generally found small but statistically significant improvements in diet and PA among those who lived in less favorable food and PA environments, contrary to our original hypothesis, and to previous findings in urban settings.[10, 11, 13, 42] In adjusted analyses, which controlled for baseline values of outcomes and socio-demographic variables, findings again indicated that those who lived in less favorable environments lost more weight and increased PA to a greater degree than those in healthier, more supportive environments. Our results could suggest a hypothesis to be tested in rural settings: when resources are less plentiful, intrinsic motivation may influence an individual's ability to make healthy changes to a greater degree than supportive environments and community resources. It could be that our intervention targeted behaviors that are easier to achieve in less favorable food environments (e.g., moderate consumption of healthy fats found in nuts, versus increasing fiber, fruits and vegetables, as the primary nutrition message), and led to improved diet and weight outcomes. Also, it may be that rural residents in disadvantaged areas are more accustomed to overcoming barriers to various goals and thus more persistent when making lifestyle changes. Finally, rural residents may be exercising in non-traditional venues (e.g., paths, churches, local schools) which were not documented in our GIS analyses.

Our findings are the opposite of Wedick et al.[10] and Feathers et al.[11] who found that a more supportive food environment (e.g., greater access to Green Carts, farmers' markets, and supermarkets) was associated with improved intervention-related outcomes. However, these prior studies included interventions focused on reducing dietary fat and increasing fruit, vegetable, and fiber consumption, and both were set in urban areas of the Northeastern United States. The different dietary guidance provided by the HHL Project, along with differences in geography, culture, and participant characteristics, may have contributed to our unexpected findings.

With regard to physical activity, Zenk et al.[12] found that access to indoor walking facilities was associated with improved adherence to a walking intervention among midlife African American women from Chicago. In two studies based in San Diego County, Kerr et al.[13] found that overweight men improved walking if they lived in less walkable neighborhoods, whereas overweight women increased PA to a greater degree if they perceived better safety from traffic. Our results are again, contrary to Zenk et al. and Kerr et al.'s findings among women,[12,13] with our findings indicating that intervention participants increased PA to a greater degree if they lived further from PA resources such as gyms. Again, this could be due to differences in geography and culture of participants in our study versus other studies.

Individually-based lifestyle interventions may be particularly important for those who live in areas with less access to health-promoting community resources. In the future, in-depth interviews or focus groups could be conducted with individuals who live in less healthy environments but who overcome barriers to healthy eating and PA and achieve measurable results, to determine factors that enable participants to overcome neighborhood barriers. In addition, future work could examine whether participants who are motivated to make healthy changes are more likely to overcome neighborhood and community-level barriers to a healthy diet and PA, as well as whether those with less motivation are more sensitive to such barriers and may need special tips on how to overcome the barriers.

This study was limited in that we only were able to include participants who had baseline and 6-month follow-up data. Thus, we potentially had inadequate power to address the research questions. The sample size for some analyses was reduced because of missing data related to lack of available crime data, step data, and GIS data. An additional limitation is the possibility of obtaining statistically significant results by chance, due to examining multiple associations. The food environment variables were significantly correlated, with distance to supermarkets strongly correlated with distance to fast food restaurants (r=0.94), indicating the complex nature of the food environment variables. In addition, many studies indicate that people do not shop at the supermarket closest to home,[41,42] so it could be that those individuals who are selecting to shop at places further from home are shopping at those locations because they have healthier food options. The 1-mile buffer used in GIS analyses is likely inadequate to define participants' neighborhoods and to encompass all trips made for food and physical activity-related activities.[31] Finally, our generalizability was limited as our sample was enrolled from one county in eastern NC.

CONCLUSION

Prior studies in urban environments suggest individuals living in healthier food and PA environments were able to make greater dietary and physical activity improvements when enrolled in lifestyle interventions, compared to intervention participants living in less healthy environments.[10–13] Contrary to prior studies in urban locations, in our rural setting, we found that those living in less resource-rich food and PA environments generally made greater improvements in diet and PA. Our findings may be due in part to differences in the type of intervention provided, differences in how a rural environment mediates efforts to improve lifestyle behaviors, differences in motivation and self-efficacy for lifestyle change among rural residents, or other factors. Further studies should be undertaken to examine these paradoxical findings, and if confirmed, to better understand them.

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Table 1

Baseline characteristics of the Heart Healthy Lenoir Study sample for those with both baseline and 6-month measures.

Characteristic	N	Mean	Standard deviation
Age in years	249	56.5	10.8
Body mass index (kg/m^2)	248	36.3	9.2
Dietary risk assessment Score	235	27.6	5.2
Carotenoid Index	207	44.1	26.6
Total self-reported physical activity time (minutes per week)	249	160.2	275.1
Pedometer-measured steps per day	194	4525	2799.0
Density (number) of supermarkets (in a 1-mile buffer)	191	0.5	0.8
Distance to closest supermarket, miles	191	2.1	1.9
Density (number) of fast food restaurants	191	1.4	2.2
Distance to closest fast food restaurant, miles	191	2.1	2.0
Density (number) of farmers' markets	191	0.1	0.3
Distance to the closest farmers' market, miles	191	3.3	2.1
Density (number) of convenience / corner stores	191	2.1	3.2
Distance to the closest convenience / corner store, miles	191	1.5	1.5
Modified Retail Food Environment Index	191	14.2	9.8
Perceived Neighborhood Nutrition Barriers	242	14.3	6.3
Density (number) of parks	191	1.0	1.4
Distance to the closest park, miles	191	2.2	2.3
Density (number) of private gyms	191	0.7	1.2
Distance to the closest private gym, miles	191	2.4	2.4
Density (number) of low cost gyms	191	0.4	0.7
Distance to the closest low cost gym, miles	191	5.0	4.6
Walk Score	242	16.0	20.2
Crime* (sum of all crimes from 11/13/2014-12/13/2014)	132	1.0	1.7
Perceived Neighborhood PA Barriers	231	29.7	12.9

*N for Crime is smaller than for other characteristics because crime rates were only available for residents of Kinston, the Lenoir County seat.

Table 2

Bivariate correlations* between intervention-related 6-month changes† in diet (self-reported, and carotenoid measured), and weight, and the food environment.

Food environment variables	Six-month change in self-reported DRA Score (higher is better)	*P*-value	Six-month change in blood carotenoids (higher is better)	*P*-value	Six-month change in weight (lower is better)	*P*-value
Density of supermarkets (higher is desirable)	−0.10	0.17	***0.17***	***0.05***	0.04	0.57
Distance to closest supermarket, miles (lower is desirable)	0.07	0.38	−0.04	0.60	0.10	0.17
Density of fast food restaurants (lower is desirable)	−0.07	0.37	0.13	0.10	0.00	0.96
Distance to closest fast food restaurant, miles (higher is desirable)	0.05	0.51	−0.03	0.71	0.05	0.46
Density of farmers' markets (higher is desirable)	−0.02	0.79	0.03	0.16	−0.10	0.16
Distance to the closest farmers' market, miles (lower is desirable)	0.08	0.26	−0.10	0.25	0.01	0.84
Density of convenience / corner stores (lower is desirable)	−0.05	0.54	0.04	0.60	−0.10	0.17
Distance to the closest convenience / corner store, miles (higher is desirable)	0.06	0.40	−0.04	0.61	0.05	0.53
Modified Retail Food Environment Index (higher is desirable)	0.01	0.85	0.00	0.97	***0.19***	***0.01***
Perceived Neighborhood Nutrition Barriers (lower is desirable)	***0.15***	***0.02***	0.03	0.68	0.02	0.79

*Pearson correlation coefficients

†Change = 6 month value minus baseline value

Table 3

Bivariate correlations* between intervention-related 6-month changes† in physical activity (self-reported total physical activity and pedometer-measured steps), and weight, and the food and physical activity environments.

Physical activity environment variables	Six-month change in self-reported Physical Activity (higher is better)	*P*-value	Six-month change in pedometer-measured steps (higher is better)	*P*-value	Six-month change in weight (lower is better)	*P*-value
Density of parks (higher is desirable)	0.00	0.89	−0.11	0.25	−0.12	0.10
Distance to the closest park, miles (lower is desirable)	0.10	0.17	0.09	0.34	0.02	0.75
Density of private gyms (higher is desirable)	−0.08	0.29	***−0.19***	***0.04***	0.08	0.25
Distance to the closest private gym, miles (lower is desirable)	0.13	0.07	0.06	0.53	0.09	0.22
Density of low cost gyms (higher is desirable)	0.00	0.93	−0.01	0.90	−0.08	0.27
Distance to the closest low cost gym, miles (lower is desirable)	0.07	0.30	0.00	0.95	−0.01	0.85
Walk Score (higher is desirable)	−0.02	0.74	−0.08	0.33	−0.03	0.59
Crime (lower is desirable)	0.00	0.99	−0.06	0.62	***−0.21***	***0.01***
Perceived Neighborhood PA Barriers (lower is desirable)	−0.04	0.56	0.02	0.82	0.01	0.83

*Pearson correlation coefficients

†Change = 6 month value minus baseline value

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Table 4

Parameter estimates, standard error, and p-values for potential moderators of the association between change in diet, physical activity, and weight, by the food and physical activity environments of Heart Healthy Lenoir participants. The independent variable in all models is the intervention. Models are adjusted for race, age, sex, and education. We present models for bivariate relationships with a p-value less than 0.10 in Tables 2 or 3.

Dependent variable	**Potential moderator**	**Parameter estimate**	**Standard error**	***P*-value**
Six-month change in blood carotenoids (higher is better)	Density of supermarkets (higher is desirable)	−2.505	1.778	0.161
	Baseline carotenoids	0.307	0.049	<0.0001
	Race (Black)	6.151	3.171	0.055
	Age	−0.052	0.139	0.708
	Sex (Male)	0.196	3.648	0.957
	Education	−0.565	0.495	0.256
Six-month change in weight (lower is better)	Modified Retail Food Environment Index (higher is desirable)	−0.065	0.026	0.012
	Baseline weight	0.001	2.392	0.556
	Race (Black)	−0.471	0.594	0.429
	Age	0.024	0.024	0.335
	Sex (Male)	0.401	0.651	0.539
	Education	−0.049	0.090	0.587
Six-month change in self-reported Dietary Risk Assessment Score (DRA) (higher is better)	Perceived Neighborhood Nutrition Barriers (lower is desirable)	0.030	0.048	0.529
	Baseline DRA	−0.579	0.057	<0.0001
	Race (Black)	−0.011	0.638	0.986
	Age	−0.020	0.028	0.463
	Sex (Male)	−0.745	0.700	0.288
	Education	0.215	0.104	0.040
Six-month change in pedometer-measured steps (higher is better)	Density of private gyms (higher is desirable)	−491.121	219.438	0.027
	Baseline pedometer-measured steps	0.170	0.092	0.069
	Race (Black)	−866.275	685.435	0.209
	Age	24.507	27.300	0.371
	Sex (Male)	17.849	712.516	0.980
	Education	110.394	107.835	0.308
Six-month change in self-reported Physical Activity (higher is better)	Distance to the closest private gym, miles (lower is desirable)	31.689	15.532	0.043
	Baseline self-reported	−0.337	0.124	0.007
	Physical Activity			
	Race (Black)	−80.390	87.718	0.361
	Age	3.825	3.575	0.286
	Sex (Male)	−56.224	94.691	0.553

Dependent variable	**Potential moderator**	**Parameter estimate**	**Standard error**	***P*-value**
	Education	−16.083	13.650	0.240
Six-month change in weight (lower is better)	Crime (lower is desirable)	0.313	0.184	0.090
	Baseline weight	−0.002	0.013	0.904
	Race (Black)	−0.961	0.728	0.189
	Age	0.027	0.033	0.424
	Sex (Male)	0.213	0.789	0.787
	Education	−0.097	0.119	0.418