The moderating role of the built environment in prenatal lifestyle interventions

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Abstract

This study examined whether the neighborhood built environment moderated gestational weight gain (GWG) in LIFE-Moms clinical trials. Participants were 790 pregnant women (13.9 weeks' gestation) with overweight or obesity randomized within four clinical centers to standard care or lifestyle intervention to reduce GWG. Geographic information system (GIS) was used to map the neighborhood built environment. The intervention relative to standard care significantly reduced GWG (coefficient = 0.05; p = 0.005) and this effect remained significant (p < 0.03) after adjusting for built environment variables. An interaction was observed for presence of fast food restaurants (coefficient=−0.007; p = 0.003). Post hoc tests based on a median split showed that the intervention relative to standard care reduced GWG in participants living in neighborhoods with lower fast food density 0.08 [95% CI, 0.03,0.12] kg/week (p = 0.001) but not in those living in areas with higher fast food density (0.02 [−0.04, 0.08] kg/week; p = 0.55). Interaction effects suggested less intervention efficacy among women living in neighborhoods with more grocery/ convenience stores (coefficient = −0.005; p = 0.0001), more walkability (coefficient −0.012; p = 0.007) and less crime (coefficient = 0.001; p = 0.007), but post-hoc tests were not significant. No intervention x environment interaction effects were observed for total number of eating establishments or tree canopy. Lifestyle interventions during pregnancy were effective across diverse physical environments. Living in environments with easy access to fast food restaurants may limit efficacy of prenatal lifestyle interventions, but future research is needed to replicate these findings.

Keywords

INTRODUCTION

Prior research has suggested that the built environment plays a role in shaping eating, physical activity, and weight status (1). The surrounding food environment, including varying types of food outlets such as fast food restaurants and convenience stores, may influence eating behavior and consequently body weight. Similarly, the availability of surrounding recreational and sports facilities, green space, or parks may influence physical activity levels and body weight regulation. Indeed, certain environments are considered to be more 'obesogenic' than others (2).

Living in built environments with specific characteristics may affect one's ability to manage body weight during lifestyle interventions. The social ecological model describes how environmental factors may interact with interventions to influence weight control (3, 4).

Living in environments with accessible parks, for example, may make it easier to increase physical activity as part of a physical activity intervention (5). Conversely, living in environments with easy access to convenience stores, providing high-energy dense snacks and few healthy foods, may handicap adherence to healthier dietary recommendations offered for weight control intervention (6).

Limited research has examined how the built environment influences the effects of prenatal lifestyle interventions targeting gestational weight gain (GWG) (7). Excess weight gain during pregnancy is an independent predictor of long-term weight gain and obesity in mothers (8, 9). The LIFE-Moms prenatal interventions significantly reduced GWG rate during pregnancy in a geographically and ethnically diverse population of US mothers (10). However, it remains unknown whether these intervention effects were moderated by built environment variables. The purpose of this study was to determine if the neighborhood built environment moderated the GWG outcomes observed as a result of the LIFE-Moms prenatal lifestyle interventions.

METHODS

This sub-study was secondary to the LIFE-Moms consortium that conducted separate randomized clinical trials to test different lifestyle intervention strategies to modify GWG in diverse populations (11). Within each site, eligible participants were randomized to the local site prenatal behavioral lifestyle intervention or to a comparison group that received either standard practice or standard practice with educational materials. LIFE-Moms participants represented a large, racially, socioeconomically and geographically diverse population of US pregnant women with overweight or obesity. Four of the seven LIFE-Moms trials elected to include this sub-study in their IRB-approved protocols. The distribution of participants across the 4 trials were as follows: 257 from California Polytechnic State University (n = 128) & Brown University in Rhode Island (n = 129); 210 from St. Luke's-Roosevelt Hospital & Columbia University in New York; 278 from Northwestern University in Chicago; and, 53 from Pennington Biomedical Research Center in Louisiana. Of the 798 participants, baseline residence address was available on 100%. The pregnancy weight measures were completed by 790 participants (99%; n = 386 standard care and n = 404 intervention) who were included in this analysis.

Measures

Assessments and clinical measurements were conducted at baseline (9–15-weeks' gestation) and 35–36-weeks' gestation. Demographics were measured by self-report. A stadiometer was used to measure maternal height in duplicate to the nearest 0.1 cm at baseline. At all assessment visits, maternal weight was assessed in duplicate to the nearest 0.1 kg using a calibrated standard digital scale with the participant in lightweight clothing without shoes. Body mass index (BMI) was calculated from height and weight (kg/m^2). GWG per week was defined as the difference between the study measured weight at 35–36 weeks' gestation and baseline weight, with the result divided by the number of weeks' (days/7) between the two visits (11). A geographic information system (GIS) was used to map attributes of the neighborhood built environment using ArcGIS 10.4 (2016) and the ESRI Street Map North

America locator (GIS software package; ESRI). ESRI Business Analyst US Businesses point dataset was used and filtered using the North American Industry Classification System (NAICS) code to plot locations of food stores (grocery, supermarkets, convenience) fast food, and full-service restaurants. Census block group polygons were enriched using the USA Crime Index dataset available via ArcGIS living atlas. The dataset assigned a score based on the total crime index in the U.S. (including personal crime, property crime, robbery, larceny, theft. etc.) by state, county, ZIP Code, tract, and block group. The U.S. Geological Survey (USGS) National Land Cover Database was used to map vegetative canopy and EPA National Walkability Index was used to map walkability at the census block group level.

Participant addresses reported at study entry were geocoded and the located results were manually reviewed to verify correct matches to street address. The match rate was 100%. Addresses given as post office boxes were mapped to the zip code centroid. Point locations representing the addresses of participants were spatially joined to the 2011 U.S. Census block group polygons and block-group levels and related to built environment factors. Both 1 km and 3 km buffers were calculated around participant address locations to operationalize neighborhood of residence for each participant (12).

Analysis

An individual participant data meta-analysis was conducted combining the data from the four randomized trials. Similar to the overall trial analysis, generalized linear mixed models (GLMM) were used to examine the effect of the intervention vs. standard care on GWG, with a random effect included for site and covariates that included baseline BMI, college education, maternal age, parity, race, and gestational age at randomization. Similar GLMM were used to examine built environment main effects and built environment by randomized group interactions in relation to GWG, including site as a random effect and covariates that included baseline BMI, college education, maternal age, parity, race, and gestational age at randomization. If an interaction term was significant ($p<0.05$), post-hoc GLMM analyses compared intervention vs. standard care effects on GWG within each built environment variable (categorized based on median split) with site as a random effect and the same covariates.

RESULTS

Participant characteristics in this sub-study did not significantly differ by randomized group and were similar to those reported for the overall trial (11). At study entry, participants were on average (SD) 13.9 (1.6) weeks gestation with a mean age of 32.2 (4.9) years and BMI of 31.4 (4.6) kg/m2 (47.2% with overweight and 52.8% with obesity). A majority reported a college education or higher (67.0%), an annual household income $75,000 (52.6%), and being married or living with a significant other (88.4%); 44.5% were nulliparous. Racial/ethnic groups were as follows: 28.3% non-Hispanic Caucasian, 14.4% Non-Hispanic African-American, 49.4% Hispanic, and 7.9% with other/more than one race. At study entry, there were within a 1 kilometer radius of participants' residences an average (SD) of 71.4 (140.0) total eating establishments, 3.8 (7.9) fast food restaurants, and 10.6 (14.2) grocery/

convenience stores. The mean walkability index score was 12.3 (4.1); the average percent green space canopy was 15.2 (15.8); and, the total crime index weighted average was 95.8 (6.0).

Similar to results of the overall trial (11), the intervention relative to standard care significantly reduced average GWG kg per week (coefficient = 0.05 [CI, 0.02, 0.09]; p = 0.005). The randomized group effect on GWG remained significant after adjusting for neighborhood density of fast food restaurants (p = 0.0005), grocery/convenience stores (p = 0.006), all eating establishments (p = 0.005), crime (p = 0.03), walkability (p = 0.005), and green space canopy (p = 0.004).

Examining environmental moderators of the group effect on GWG, a significant interaction was observed for fast food restaurants (Table 1; coefficient =−0.007 (95% CI, −0.012, −0.003; p = 0.003). Post hoc GLMM tests based on median split indicated that the intervention reduced GWG by 0.08 [95% CI, 0.03,0.12] kg/week (p = 0.001) in women living in areas with lower fast food density but had no significant effect in women living in areas with higher fast food density (0.02 [−0.04, 0.08] kg/week; p = 0.55; Figure 1). Modest but significant interaction effects on GWG were observed for other variables (Table 1) and suggested less intervention efficacy among women living in neighborhoods with more grocery/convenience stores (coefficient = −0.005; p = 0.0001), more walkability (coefficient −0.012; p = 0.007) and less crime (coefficient = 0.001; p = 0.007). However, post-hoc tests analyzing intervention effects within median-split subgrouping of these built environment domains were not significant. Analyses without covariates and also using a 3 km buffer were explored but yielded similar findings (data not shown).

DISCUSSION

Despite different approaches among these four LIFE-Moms clinical sites, lifestyle interventions during pregnancy were effective in reducing GWG across diverse populations, clinical settings, and physical environments. The most significant built environment moderator of intervention efficacy was density of fast food restaurants. The interventions reduced GWG among women living in neighborhoods with lower but not higher fast food restaurant density.

This study is the first known to explore the built environment as a potential moderator of the efficacy of prenatal interventions aimed at reducing GWG in a sample of ethnically diverse pregnant women with overweight or obesity. In this randomized trial, GWG was objectively measured. Limitations in this study included the frequency and scope of environmental variables and buffers selected (12). The study examined the influence of the built environment surrounding participants' home residences but not work or other relevant locations (13). The degree of variance in built environment values was high, and thus these findings should be replicated in future research. While our analyses included several a-priori covariates, employment was not included due to inconsistencies in this measure across LIFE-Moms trials. Since only a subset of trials from the LIFE-Moms consortium were included this sub-study, it is possible that a different pattern of results could be found with the inclusion of all trials.

In sum, prenatal lifestyle interventions were effective in reducing GWG in women living in diverse environments. Living in environments with easy access to fast food restaurants may limit efficacy of prenatal lifestyle interventions, but future research is needed to replicate these findings. Future research is also needed to directly address the influence of the built environment away from home (e.g., work) (13) and include measures of dietary and physical behaviors to better understand the mechanisms through which the built environment may moderate intervention efficacy.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements:

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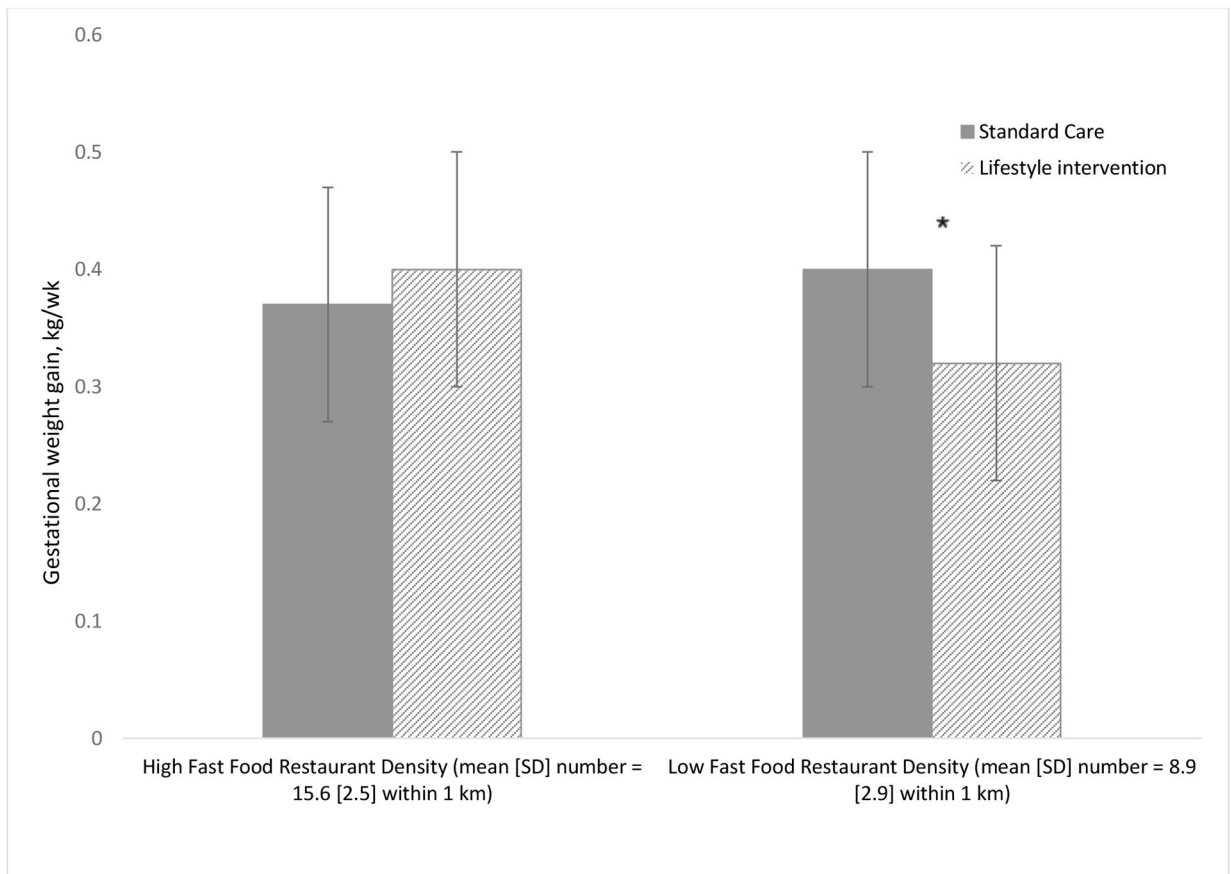
Figure 1.
Gestational Weight Gain (GWG; mean, 95% CI) in Standard Care and Intervention Groups in neighborhoods with high and low fast food restaurant density. The Intervention reduced GWG (*p = 0.001) in areas with lower fast food density but not in areas with higher fast food density (p = 0.55).

Table 1.

Environmental moderators of prenatal lifestyle intervention (N = 390) vs. standard care (N = 408) effects on gestational weight gain

Environmental variable	Environmental variable main effect coefficient [95% CI]	Environmental variable x randomized group interaction coefficient [95% CI]
Fast food restaurants	0.002 [−0.002, 0.006]; p = 0.31	−0.007 [−0.012, −0.003]; p = 0.003
Grocery/convenience stores	0.001 [−0.001, 0.003]; p = 0.19	−0.005 [−0.007, −0.002]; p = 0.0001
Walkability Index Score	0.001 [0.003, 0.02]; p = 0.01	−0.012 [−0.021, −0.003]; p = 0.007
Tree canopy	−0.0001 [−0.0002, −0.002]; p = 0.89	0.0001 [−0.002, 0.002]; p = 0.95
Total crime index	−0.0001 [−0.0001, 0.0001]; p = 0.99	0.001 [0.0001, 0.001]; p = 0.007

CI= confidence interval

Environmental variables were based on 1-kilometer radius around participants' residences. Model coefficients are from generalized linear mixed models that examined built environment main effects and built environment by intervention group interactions in relation to gestational weight gain, including site as a random effect and covariates that included baseline BMI, college education, maternal age, parity, race, and gestational age at randomization.