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WASHINGTON UNIVERSITY IN ST. LOUIS

Department of Psychology

The Impact of the Built Environment and At-Home Calorie Consumption on Family-based Behavioral Weight Loss Treatment Outcomes

by

Myra Altman

A thesis presented to the
Graduate School of Arts and Sciences
of Washington University in
partial fulfillment of the
requirements for the
degree of Master of Arts

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Introduction

Childhood obesity rates have risen dramatically over the last three decades and pose a considerable cost to individuals and society. The prevalence of pediatric overweight (defined as BMI at or above the 85^{th} percentile and lower than the 95^{th} percentile for children of the same age and sex according to the Center for Disease Control, (Kuczmarski et al., 2000)) and obesity (defined as BMI $\geq 95^{th}$ percentile) is estimated at 31.8% (Ogden, Carroll, Kit, & Flegal, 2012), with 16.9% of children classified as obese. Pediatric obesity has many consequences for the individual, including serious medical conditions, psychological and psychosocial problems, and poor quality of life (August et al., 2008; BeLue, Francis, & Colaco, 2009; Deitz, 2002; Hampl, Carroll, Simon, & Sharma, 2007; Luppino, de Wit, Bouvy, Stijnen, Cuijpers, Penninx, & Zitman, 2013), and for society, in the form of a significant public health burden (Wolf & Colditz, 1998). A socioenvironmental framework including individual, family, peer, and community levels has been proposed to understand the multiple factors that contribute to the etiology and maintenance of overweight. A deeper understanding of how these different levels interact is crucial to intervene effectively with childhood overweight and obesity (Huang, Drewnosksi, Kumanyika, & Glass, 2009). The socioenvironmental model of obesity is shown in Figure 1 (adapted from Wilfley, Vannucci, & White, 2010).

Family-based treatment (FBT) is considered the "gold-standard" for the treatment of childhood overweight and is effective in achieving weight loss across diverse populations (Epstein, Paluch, Roemmich, & Beecher, 2007). However there has been little research into which components of the treatment produce change. The goal of FBT is to facilitate sustainable weight loss via two primary components: 1), reducing caloric intake through dietary modifications, and 2) increasing caloric expenditure through physical activity (PA). Food prepared at home tends to be healthier than food prepared outside of the home (Guthrie, Lin, & Frazao, 2002) so one target of FBT dietary intervention is to increase the proportion of calories that are consumed at home. From a socioenvironmental perspective, this change occurs at the individual and family levels but may also be influenced by the broader community. The goal of the present study is thus to examine the effect of increasing the proportion of calories consumed at home on weight loss outcomes and to evaluate whether an individual's neighborhood influences their ability to make this dietary change.

Background

The increased tendency to consume foods prepared outside of the home may be contributing to high obesity rates. Recent estimates suggest that American families consume a third of their calories away from the home, 20% of which is fast food (Adair & Popkin, 2005). Research has also shown that, compared to food prepared at home, food consumed outside of the home tends to be higher in fat content and lower in nutritional quality (Guthrie et al., 2002) and served in larger portion sizes containing more calories (Ayala et al., 2008). In addition, overweight and obese children eat more meals away from the home than their normal weight counterparts (Gillis & Bar-or, 2003), and rates of child overweight and obesity are higher in families who eat at least one meal away from the home per week (Ayala et al., 2008). Eating food away from home is also associated with increases in body mass index (BMI) over time. In one study, girls who ate more food away from home were more likely to show increases in BMI over time (Thompson et al., 2004), and consuming breakfast away from home led to an increase in BMI over time in a Hong Kong sample of children (Tin, Ho, Mak, Wan, & Lam, 2012). In contrast, youth who eat more meals prepared at home (greater than six family meals per week) had improved dietary outcomes including better dietary patterns (less breakfast skipping) and nutritional intake (increased fruit and vegetable intake; Videon & Manning, 2003). Given the relatively poorer nutritional quality of meals prepared outside of the home it is not surprising that recent evidence-based recommendations on the prevention and treatment of childhood obesity recommend limiting the amount of food consumed outside of the home at restaurants or fast food venues (Spear et al., 2007).

The extent to which one consumes food outside of the home may depend on what is available in your built environment. The built environment refers to physical and social features in the surroundings that are person-made, including urban design, land use, and transportation systems (Papas et al., 2007; Thornton, Pearce, & Kavanagh, 2011). See Appendices A and B for a summary of built environment variables discussed in this paper. Researchers have examined the role of the neighborhood built environment on obesity and overweight, with findings overwhelmingly showing that the built environment (e.g., how walkable the neighborhood is, how much access people have to fast food outlets) influences obesity in adults (Booth et al., 2005). However, research on the role of the built environment on child energy balance behaviors (diet and PA) is more limited and remains inconclusive.

A recent review of the literature examining the association between neighborhoods and child overweight reported several significant associations but noted that as of yet, no clear relationship between the neighborhood environment and overweight and obesity had been established (Carter & Dubois, 2010). In this review neighborhood features associated with higher child overweight include greater access to and prevalence of retail food establishments, further distance to a supermarket, and neighborhood disadvantage; while better neighborhood walkability (neighborhood street layout, intersection density, land-use mix, and the number of

PA facilities) and better parental perceived access to stores were associated with lower overweight.

Research examining the direct role of the built environment on dietary behaviors is even more limited and similarly inconclusive, particularly for children. For children, research has shown that living in a neighborhood with more access to unhealthy food outlets (Jennings et al., 2011), socioeconomic disadvantage, or no grocery store within 1 km (Pabayo, Spence, Cutumisu, Casey, & Storey, 2012) are associated with increased sugar sweetened beverage consumption. No consistent evidence has been shown linking the built environment to fruit and vegetable intake, breakfast consumption, or diet more generally (De Vet, De Ridder, & De Wit, 2011).

To date only one study has examined the potential role the built environment may play in child weight loss treatment success. Epstein and colleagues (2012) analyzed built environment data from children in four separate FBT weight loss intervention studies and found that access to parks and increased block size were associated with more weight loss, while more convenience stores and supermarkets in children's' neighborhood were associated with less weight loss. This is different from earlier findings suggesting that proximity to a supermarket is related to lower weight. Other variables assessed included housing density, park plus recreational area, and grocery stores, none of which were significantly related to weight loss. Thus, it appears that the built environment may play an important role in the treatment of childhood overweight. However, more research is needed to examine which specific environmental factors influence diet, and the mechanisms by which they do so.

Current Study

The present study seeks to add to the literature on the treatment of childhood overweight and obesity by examining 1) the effect of increasing the proportion of calories consumed at home (a treatment target) on weight loss outcomes, and 2) the role of the built environment in making this change. There are two primary hypotheses. First, increasing the proportion of calories consumed at home will be associated with greater reduction in standardized BMI (zBMI) following FBT. Second, features of the built environment will influence the magnitude of change in the proportion of calories consumed at home. To our knowledge, this is the first study to examine the influence of changing the proportion of calories consumed at home on weight loss treatment outcomes, and the first study to examine the effect of the environment on this specific dietary modification. Given the inconsistent findings across this literature and the novelty of the research questions, the present study will use exploratory analyses to identify environmental features that may be associated with this dietary change.

Methods

The current study was part of a larger randomized control study (R01HD36904; "Childhood Obesity Treatment: A Maintenance Approach"; PI: Wilfley) examining the efficacy of different weight maintenance programs following FBT for weight loss.

Participants

Participants in the weight maintenance trial were 241 child-parent dyads. Children were between the ages of 7-11 and were overweight or obese (BMI $\geq$ 85% for age and sex based on CDC growth curves; Kuczmarski et al., 2000), and all children had at least one overweight parent (BMI > 25).

Participants were recruited in the Saint Louis, Missouri and Seattle, Washington areas through local media outlets, schools, organizations, pediatrician referrals, weight management clinics, and word-of-mouth. Families were excluded from the trial if either the parent or child had an eating disorder, drug or alcohol dependence, or other mental illness diagnosis; low English comprehension; a physical illness or disability that prohibited following dietary recommendations or engaging in moderate to vigorous PA; or a new medication that could affect weight. Written informed consent and verbal assent were obtained from parents and children, respectively. Research approval was obtained from the Institutional Review Boards at both sites.

Geographic information system (GIS) data were gathered for individuals who completed FBT (N =116) and were living in the City of Saint Louis and Saint Louis County, Missouri and King County, Washington. Three participants moved over the course of FBT and thus were excluded from these analyses because objective built environment data were only obtained based on where they lived at baseline, resulting in a final sample size of 113 families for the present analyses.

Procedure

Trained research assistants with at least a bachelors-level education administered baseline assessments over two visits. Subsequently, participants received 16 weeks of FBT. Post-treatment measures were taken following the completion of FBT. Participants were then randomized to different weight loss maintenance treatments. This study will examine only the FBT phase of the trial.

Intervention

FBT was delivered across 16 weeks, with a 30-min individual family meeting and separate 45-minute child-only and parent-only group meetings every week. FBT is a lifestyle program that targets 1) reducing energy intake (daily caloric goals are calculated for each participant (parent and child) based on height, age and activity level) and improving diet quality, and 2) increasing physical activity (goal of 90 minutes per day for children, and 60 minutes per day for adults, at least 5 days a week). The intervention promoted changes for both parents and children through behavioral modification strategies including self-monitoring, self-regulation, and stimulus control.

Measures

Anthropometrics. Child weight and height were measured at baseline and following FBT. Weight and height measurements were taken in light clothing with shoes removed on a calibrated electronic scale and stadiometer. An average of three weights (measured to the nearest 0.1kg), and three heights (measured to the nearest 0.1cm) were calculated for each child. Child BMI was calculated (kg/m^2) and standardized according to age and gender based on CDC growth curves (zBMI; Kuczmarski et al., 2000).

Demographics. Parents completed a brief demographic questionnaire reporting child age, gender, and race/ethnicity. For the current study, race was categorized as Caucasian/White, Black/African American, or Other, and ethnicity as Hispanic/Non-Hispanic. The Barratt Simplified Measure of Social Status, a measure adapted from the Hollingshead index of social status (Hollingshead, 1975), was used to assess parents' and grandparents' occupation and level of education as a proxy for socioeconomic status (SES; Barratt, 2006). Higher values indicate higher SES.

Dietary intake. At both baseline and post-treatment, all participants completed telephone-administered 24-hour dietary recalls using the Nutrition Data System for Research (NDS-R version 2009, Nutrition Coordinating Center, University of Minnesota). Interviews were completed by a registered dietician or a trained bachelors-level nutritionist following standard protocols using the multiple-pass method. Parents completed the dietary recall for the child but were assisted by the child if present. Recalls were administered on nonconsecutive days, including at least one weekday and one weekend day. Mean caloric intake was calculated each day and categorized as consumed at home or away from home. When there was a discrepancy between where the meal was prepared versus eaten, the food was coded for where it was prepared (e.g., if child ate lunch at school but it was made at home, it was recorded as calories consumed at home).

Objective environmental variables. Objective measures of the neighborhood built environment were calculated separately for each participant. Data were collected using a combination of GIS sources (see Table 1). Participants' neighborhoods varied in size depending on the particular built environment characteristic. Measures of walkability (e.g., land use, employment density, household density, street connectivity, speed limit, and street type) were mapped based on a ¼-mile network domain (circular buffers around each participant's home, including the areas of all parcels accessible within ¼ mile along the road network). This domain was selected in the absence of empirical data on the appropriate buffer sizes to use for youth because it represents a likely distance that children are willing to walk for utilitarian purposes. Measures of the food environment and availability of recreational facilities were calculated using 1-mile radial domains, as this represents a close driving distance. A description of all the objective environmental variables is included in Appendix A.

Perceived environmental variables. At baseline parents completed the Neighborhood Environment Walkability Scale – Abbreviated (NEWS-A), a self-report measure of neighborhood characteristics. The NEWS-A consists of eight subscale scores and four individual items. A description of all the subscales and individual items is included in Appendix B. The longer form of the NEWS survey has adequate test-retest reliability (.58-.80) and convergent validity with objective measures of PA (Saelens, Sallis, Black, & Chen, 2003). Both the NEWS and the NEWS-A have adequate levels of factorial and criterion validity (Cerin, Saelens, Sallis, & Frank, 2006).

Data Analysis

All analyses were conducted using the SPSS version 20.0 software package (SPSS Inc., Chicago, IL). All participants in the present analyses completed the FBT phase of treatment (prior to participant randomization into maintenance conditions), and thus all analyses will be completer analyses (N=116). T-tests were used to examine change in zBMI and change in the proportion of calories consumed at home between baseline and posttreatment. To identify covariates to use in the analyses, bivariate correlations were used to examine the relationships among demographics and baseline variables (gender, age, race/ethnicity, SES, site, baseline proportion of calories consumed at home, baseline zBMI), independent variables, and outcome variables.

The present study consisted of two primary sets of analyses, with two primary outcome variables: the change in zBMI and the change in the proportion of calories consumed at home between baseline and posttreatment. Change scores were calculated by subtracting baseline scores from posttreatment scores. Therefore, a negative change in zBMI indicated increased weight loss, and a positive change in the proportion of calories consumed at home indicated an increased proportion of calories consumed at home (i.e., better adherence to treatment recommendations). Both outcome variables were measured and used as continuous variables.

First hypothesis. *Increasing the proportion of calories consumed at home will be associated with greater reduction in zBMI following FBT*. These analyses examined the association between the change in the proportion of calories consumed at home and the change in zBMI between baseline and posttreatment. The association between the change in the proportion of calories at home and zBMI was tested using a hierarchical linear regression predicting child change in zBMI following treatment by change in the proportion of calories consumed at home. Relevant covariates were included in the first step of the model, and change in the proportion of calories consumed at home was entered into the second step.

Second hypothesis. *Features of the neighborhood built environment will influence the magnitude of change in the proportion of calories consumed at home*. The second set of analyses examined the association between the neighborhood built environment and the change in the proportion of calories consumed at home. Given the extensive number of objective built environment variables, an exploratory factor analysis (EFA) was used as a data reduction technique to identify underlying factors. Hierarchical linear regression analyses were used to examine the influence of the built environment variables on the change in the proportion of calories consumed at home. Two separate models were used to assess the role of 1) the objective environment (using factors from the EFA and individual variables) and 2) the perceived environment on change in the proportion of calories consumed at home. Relevant covariates were entered into the first step of the model, and environmental variables were included in the second step of each model. All environmental variables were placed into the model together to account for the neighborhood context.

Results

Sample Characteristics

Of the 113 children included in these analyses, the mean child age was 9.49 (*SD* = 1.30) and 67.3% were female. The sample was relatively diverse in terms of race and ethnicity: 65.5% identified as Caucasian/White, 23.9% identified as Black/African American, 10.6% identified as Other, and 9.7% identified as Hispanic. The mean SES level was 44.46 (*SD* = 10.91) on a scale from 8-66.

Participants included in these analyses (N=113) did not significantly differ from the full sample (N=241) with regards to child gender, age, race/ethnicity, baseline zBMI, and baseline proportion of calories consumed at home. However, participants in the present analyses had a slightly higher SES than participants not included, $t(231) = -2.239$, $p < .05$). Baseline characteristics of the full and analytic samples are shown in Table 2.

Change in Outcome Variables

Between baseline and posttreatment, participants achieved a significant decrease in zBMI (M=2.14 (SD=0.43) to M=1.87 (SD=0.62), $t(DF) = 11.047$, $p < .001$). The proportion of calories consumed at home between baseline and posttreatment increased from M=0.60 (SD=0.22) to M=0.65 (SD=0.24), and this change approached significance ($t(DF) = -1.829$, $p = .07$).

Change in At-Home Calorie Consumption and Weight Loss Outcomes

A hierarchical linear regression was used to examine the effect of change in the proportion of calories consumed at home on the change in child zBMI. Based on significant bivariate correlations, the proportion of calories consumed at home at baseline, change in total calories consumed, site, and SES were entered into the first step of the regression as covariates. Change in the proportion of calories consumed at home significantly predicted change in zBMI

(β=-.268, *p* = .009), with an increase in the proportion of calories consumed at home related to increased weight loss. Change in the proportion of calories consumed at home accounted for 4.2% of the variance in change in zBMI.

Exploratory Factor Analysis

An EFA was used to reduce the number of objective built environment variables in the present study. Twenty-four variables were initially entered into the EFA (see Appendix A for a list). A principal axis factor analysis was run using promax rotation with Kaiser normalization. The resulting scree plot was subsequently examined using Catell's method (1966) to find the point where the shape of the curve begins to become horizontal. Using this method, it appeared that extracting three factors would be appropriate. All of these eigenvalues were above 1.5 (8.45, 2.46, and 1.89, respectively), exceeding the commonly accepted eigenvalue cut-off rule of 1 (Kaiser, 1960). Seven items did not have adequate loading on any factors (based on the .32 cutoff suggested by Tabachnick and Fidell (2007)). These were removed from the EFA and used as individual predictors of the outcome variable.

Table 3 shows the factor loadings for the three-factor solution. This accounted for 59.3% of the variance. Variables that loaded on Factor 1 (labeled 'food environment') appeared to relate to the food environment in the neighborhood (e.g., count of restaurants and healthy food outlets), although household density, typically more associated with race/ethnicity/SES (Chambers et al., 2010) loaded on this factor as well. Items that loaded on Factor 2 (labeled 'physical environment') were associated with the physical environment of the neighborhood (e.g., walking area, the number of parks and amenities) and commercial factors (e.g., percent commercial, employment density). The third and final factor (labeled 'neighborhood disadvantage') appeared to be related to the relative economic disadvantage of the neighborhood (e.g., percentage of population below the poverty line and concentrated neighborhood disadvantage).

Only two variables – the count of convenience and general stores, and the count of schools – loaded on more than one factor. The count of convenience and general stores loaded on both Factor 1 (food environment) and Factor 3 (neighborhood disadvantage), although it loaded more strongly on Factor 1 (difference = .262). It has been suggested that more socioeconomically disadvantaged neighborhoods have more convenience stores than other food stores (such as supermarkets) (e.g., Lovasi, Hutson, Guerra, & Neckerman, 2009), which may explain this dual loading. The count of schools loaded on both Factor 2 (physical environment) and Factor 3 (neighborhood disadvantage), with a stronger loading on Factor 2 (difference = .11). The factors were all significantly correlated with each other. The food environment was most highly correlated with walkability (r = .679, p < .001) and neighborhood disadvantage (r = .430, p<.001). Walkability and neighborhood disadvantage were also significantly correlated (r = .217, p < .001). Correlations between objective and perceived environmental variables ranged from -.352 to .471

Environmental Factors and Change in the Proportion of Calories Consumed at Home

Objective environmental variables. A hierarchical linear regression was used to establish the relationships between the objective built environment and change in the proportion of calories consumed at home. Based on bivariate correlations, the proportion of calories consumed at home at baseline and change in total calories consumed were related to the dependent variable, and were included as covariates in the model. Child race, SES, and site were correlated with at least one independent variable and were also included as covariates in the model. All covariates were entered together in the first step of the hierarchical regression, and all objective environmental variables were included in the next step. The full objective environmental model (second step) was not significantly related to the outcome variable (F = 1.573, $p > .05$). Two variables significantly predicted a change in the outcome variable, controlling for all other objective environmental variables. Results from this analysis are shown in Table 4. Larger residential parcel area (size of the plot of residential land, in acres) significantly predicted an increase in the proportion of calories consumed at home ($\beta = .010$, $p < .05$), and a lower percentage of the neighborhood that is residential significantly predicted an increase in the proportion of calories consumed at home ($\beta = -.003$, $p < .05$).

Perceived environmental variables. A hierarchical linear regression was also used to establish associations between the perceived built environment and change in the proportion of calories consumed at home. Based on bivariate correlations, the proportion of calories consumed at home at baseline and change in total calories consumed were associated with the outcome variable and were included as covariates in the model. Site, SES and child race and sex were also included as covariates based on their correlations with the independent variables. All covariates were included in the first step of the hierarchical regression, and all perceived variables were included in the second step. The full perceived environmental model (second step) was not significantly related to the outcome variable (F = 1.815, $p > .05$). Two variables significantly predicted a change in calories consumed at home. Results from the analysis are shown in Table 5. Higher perceived land use access ($\beta = .052$, $p < .05$) and living in a neighborhood perceived to have more cul-de-sacs[1] ($\beta = -.044$, $p < .05$) were significantly related to an increase in the proportion of calories consumed at home, controlling for all other perceived environmental variables.

[1] A lower score on ‘cul-de-sacs’ indicates perception that there are more cul-de-sacs in the neighborhood.

Discussion

Increasing the amount of food prepared and eaten at home is a treatment target of FBT. The current study suggests that this treatment target has an important influence on relative weight outcomes following treatment. Specifically, results indicate that an increase in the proportion of calories consumed at home was significantly associated with decreases in child zBMI, controlling for the total change in calories and the baseline proportion of calories consumed at home. This finding illustrates the role of cooking and preparing meals and snacks at home and reinforces the importance of promoting this during treatment.

The current study also evaluated the role of the neighborhood built environment on this dietary change. Results of the regression examining the influence of the objective built environment indicated that living in a residence that has a larger plot size, and living in a neighborhood with a lower percentage of land used for residential purposes predicted an increase in the proportion of calories consumed at home. The role of both of these variables in increasing the proportion of calories consumed at home is not obvious. While these analyses controlled for SES, it is possible that living on a larger residential property (regardless of the rest of your neighborhood features) is indicative of higher SES, which may be related to an increased ability to prepare foods at home, which can be more costly than eating outside of the home (Guthrie et al., 2002). Alternatively, outside of SES or affordability factors, people who choose to live on larger properties may be more interested in having outdoor recreation spaces, which may be indicative of a preference for health-related behaviors, and thus instruction to increase the proportion of calories at home is more readily adopted.

Similarly, decreased residential density (controlling for commercial density) implies that more of the neighborhood area is used for other purposes, which may include more general open green space and imply a more generally health conscious neighborhood, which may facilitate healthy dietary changes. More research into the role of residential plot size and density is necessary to understand fully their role in health behaviors, including increasing calories consumed from home.

This study also assessed the role of the perceived neighborhood environment on participants' change in the proportion of calories consumed at home. Given the age range of the children in the present study (7-11), it is hypothesized that parents are responsible or assist with many of the behavioral changes recommended in treatment, and thus parental neighborhood perception may be an important indicator of the extent to which the neighborhood facilitates making treatment-suggested changes. An increase in perceived land use access predicted a significantly larger change in the proportion of calories consumed at home, controlling for other perceived features of the neighborhood environment. High scores on land use access indicate that participants perceive there to be many things (including stores and transit stops) within easy walking distance of their homes. A separate subscale of the NEWS-A survey assesses the perceived density of facilities (e.g., supermarket, fast food restaurant, library, gym, etc.) in the neighborhood. This suggests that parents' perception that they can easily access facilities in their neighborhood is important for making suggested dietary changes, regardless of the perceived density of the facilities themselves. Past research has found that parental perceived access to neighborhood facilities protected against childhood overweight and obesity (Veugelers, Sithole, Zhang, & Muhajarine, 2008), indicating that perceived access may play an important role in parents ability to promote healthy behaviors in their children.

Living in a neighborhood that is perceived to have more cul-de-sacs was also predictive of an increased change in the proportion of calories consumed at home. It has been suggested that cul-de-sacs provide a quiet, safe space for children to play, away from fast-moving traffic (Southworth & Ben-Joseph, 2004). This finding may therefore indicate that parents' perceptions of how safe it is for their children to play in their neighborhood may influence participants' changes in dietary behavior, although the mechanism by which this happens is not clear. It is also possible that parents who choose to live in areas with cul-de-sacs are more concerned with child safety and activity and are also more dedicated to making healthy dietary changes. More research is needed to examine the role of cul-de-sacs on changes in diet.

It should be noted that no food environment variables were significantly associated with a change in the proportion of calories consumed at home. This may be because food environment variables are not associated with dietary change, or that these variables are not as significant for families who engage in and complete weight loss treatment. Further research is therefore needed to examine the role of the food environment on dietary behaviors in non treatment-seeking overweight and obese children and parents. Alternatively, it is possible that by using a factor measure of the objective food environment and non-food-specific measures of the perceived environment, any effects of the food environment on this dietary change were not elucidated in this study.

Implications

Understanding the importance of calories consumed at home has implications for both prevention and treatment of childhood overweight and obesity. Multiple barriers exist to preparing and consuming meals at home, including cost, knowledge of healthy options and how to prepare them, and time (Guthrie et al., 2002). These results suggest that treatment for child weight loss should continue to emphasize the importance of preparing meals and snacks at home, and that helping families problem solve ways to overcome potential barriers (e.g., identify healthy, easy-to-prepare recipes, prepare grocery store lists, etc.), may enhance their weight loss success. It may also be effective to teach these skills directly through cooking classes and other skills training, although the efficacy of this approach will need to be established. In addition, it may be beneficial to emphasize the skills needed to prepare healthy foods for oneself at an early age – perhaps including meal preparation skills and nutrition knowledge in early education.

While the relationship between changing the proportion of calories consumed at home and the built environment is not fully clear from these analyses, it appears that neighborhood features may influence families' ability to make dietary changes. It may therefore be important to address the influence of the neighborhood during treatment by understanding how an individual's neighborhood helps or hinders their weight loss goals and helping them to be successful within that environment (e.g. think about what facilities are available in the neighborhood and how they may be accessed, etc.)

Limitations

There are limitations to the present study that should be noted. First, the theoretical model underlying these analyses assumes that treatment causes participants to change the proportion of calories consumed at home, and that the built environment moderates this change. However, because treatment in the present study is unmodeled (all participants received the same treatment) this model cannot be tested directly. Therefore, whether treatment is causing the change in the proportion of calories consumed at home remains unclear, and the effects of the built environment found to be significant for this dietary change appear to be direct effects. Future research should examine directly whether treatment is leading to this dietary change and whether the built environment moderates the effect of treatment. In addition, although it is assumed that change in the proportion of calories consumed at home causes weight loss, we do not have multiple time-point measures of these variables and therefore cannot establish temporal precedence and causality.

In addition, this sample is drawn from a larger sample of treatment-seeking families, and subsamples differ on both geographic location and SES. The generalizability of these findings to families living in different geographic locations (e.g., more rural) and of different SES is therefore limited. In addition, because this sample is drawn from a treatment-seeking population, it is not clear if the findings will generalize to non-treatment-seeking overweight or obese families, who may differ in level of motivation.

Several limitations of research on the built environment must also be noted. First, the literature on the role of the built environment on weight and energy balance behaviors is not conclusive, and there is limited consistency on which variables are examined and how they are measured. Given the lack of consensus, it is difficult to select variables and generalize findings, making it difficult to develop a broad knowledge base of the effect of the built environment on diet, PA, and weight. Second, we cannot differentiate whether families' built environment is influencing people's behavior and/or if people choose to live in neighborhoods that reflect their behavioral preferences (e.g., someone who likes walking may choose to live near a park, or someone may start walking because they live near a park). Furthermore, in this study we only include information about the built environment in an individual's immediate neighborhood (defined as a 0.25- to 1-mile radius), but that does not account for the environment that is accessible to them beyond that radius (e.g., individuals may live in a neighborhood with no supermarkets but have a supermarket on the way home from work). Future research could examine the actual routes taken and interaction people have with their immediate and broader neighborhoods using Global Positioning System tracking or other methods.

Finally, dietary data were only available for one to three days, and it is possible that this is not reflective of general dietary intake. However, this is suggested to be a very accurate measurement technique (Johnson, Driscoll, & Goran, 1996).

Future Directions

Future directions for this research include examining potential mediators of the relationship between change in the proportion of calories consumed at home and weight loss. A likely mediator is that the calories participants consumed at home are healthier, although this will need to be examined in future analyses looking at the nutrient breakdown of calories consumed at home compared to those consumed away from home. Future research could also directly examine the impact of treatment on the change in the proportion of calories consumed at home by comparing groups who receive treatment to those who do not, or comparing treatment that encourages the consumption of calories from home to one that does not. It will also be important to study other treatment targets of FBT to better understand the active ingredients of treatment. In addition, the effect of changes in PA on weight loss, and the role of the neighborhood built environment in making this change, should be included in future research.

Conclusion

The results of the present study suggest that increasing the proportion of calories that you consume from home improves weight loss treatment outcomes, indicating that this is an important treatment target. The relationship between the built environment and dietary changes is harder to distinguish, although the present research suggests that the objective built environment and individuals' perceptions of their neighborhood may be important in facilitating this dietary change. Further research is needed to understand better the role of the built environment on dietary changes and the effect of particular dietary changes on weight loss success.

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Tables and Figures

Table 1

Description of GIS Data Sources

Domain	St. Louis data source (year)	Seattle data source (year)
Walkability		
Land use	East-West Gateway Council of Governments parcel data (2008)	Urban Form Lab Original source: King County GIS 2011
Employment density	Longitudinal Employer Household Dynamics (LEHD, 2009)	Longitudinal Employer Household Dynamics (LEHD, 2009)
Household density	U.S. Census (2010)	U.S. Census (2010)
Connectivity	Street centerlines, St. Louis County Planning (2010)	King County GIS 2011
Speed limit	Street centerlines, St. Louis County Planning (2010)	King County GIS 2011
Street type	Manual via Google maps (2011)	Manual via Google maps (2011)
Physical activity facilities		
Open space	East-West Gateway Council of Governments (2007) ESRI US Major Park Local parks websites (2011)	Urban Form Lab Compiled in 2008 from King County and 39 municipalities' data
Physical activity establishments	Field data collection (2011) InfoUSA (2011)	Manual via querying of Walkscore (2011)
Schools	Mark Hogrebe, WUSTL (2011)	NCES
Retail food outlets		
Food establishments	Field data collection (2011) InfoUSA (2011)	Public Health Seattle King County 2008
SES and demographics		
Socio-demographics and SES	American Community Survey 2005-2009	American Community Survey 2005-2009

Table 2

Participant Characteristics at Baseline (Present Sample and Whole Sample)

Variable	**Present Sample (N=113)**	**Whole Sample (N=241)**	**Difference Between Samples (p-value)**
Age	9.97 (1.35)	9.88 (1.29)	0.622
Gender, % Female	67.3 (N=76)	62.7 (N=151)	0.165
SES	44.46 (10.91)	43.09 (10.39)	**0.026**
Race (%)			0.393
Caucasian	65.5 (N=74)	69.3 (N=167)	
African American	23.9 (N=27)	15.4 (N=37)	
Other	10.6 (N=12)	15.4 (N=37)	
Ethnicity (% Hispanic)	9.7 (N=11)	10.4 (N=25)	0.761
zBMI	2.14 (.43)	2.23 (0.33)	0.101
Proportion of Kilocalories Consumed at Home	0.61 (0.21)	0.57 (0.19)	0.193

- All values are mean (SD) unless otherwise indicated

Table 3

Exploratory Factor Analysis Factor Loading

Variable	Factor 1: Food Environment	Factor 2: Physical Environment	Factor 3: Neighborhood Disadvantage
Count Supermarkets	.568*	.275	-.176
Count Convenience and General Store	.657*	-.087	.395*
Count Chain Quick Service	1.081*	-.262	-.194
Count All Restaurants	.914*	.104	-.101
Count Healthy Food Outlet	.544*	.259	.143
Count Unhealthy Food Outlets	1.033*	-.203	.164
Household Density	.455*	.273	.033
Percent Commercial	.019	.519*	.147
Employment Density	-.120	.401*	-.105
Effective Walking Area	.007	.621*	.012
Count Parks	.060	.814*	.003
Count Amenities	.198	.657*	.055
Count Private Amenities	.295	.524*	-.280
Count Public Amenities	-.208	.655*	-.029
Count Schools	.125	.430*	.320*
Percentage of Population Below Poverty	-.003	-.085	.883*
Concentrated Neighborhood Disadvantage	-.127	-.020	.905*

Table 4

Regression Predicting Change in Calories at Home by Objective Built Environment

Variables	B	Standardized Beta	t	p-value
Factor 1: Food Environment	.007	.027	.216	.830
Factor 2: Walkability	-.048	-.167	-1.079	.284
Factor 3: Neighborhood Disadvantage	-.043	-.148	-1.522	.132
Presence of 40MPH Roads	-.028	-.050	-.590	.557
Street Type	-.015	-.064	-.704	.484
Park Acreage	-9.890E-6	-.019	-.221	.825
Distance to park (miles)	-.083	-.123	-1.268	.208
Distance to school (miles)	-.009	-.113	-1.297	.198
Parcel Area (acre)	.010	.186	2.190	**.031**
Percent Residential	-.003	-.212	-2.268	**.026**

- Controlling for change in total kilocalories consumed, baseline calories consumed at home, site, SES, child race.

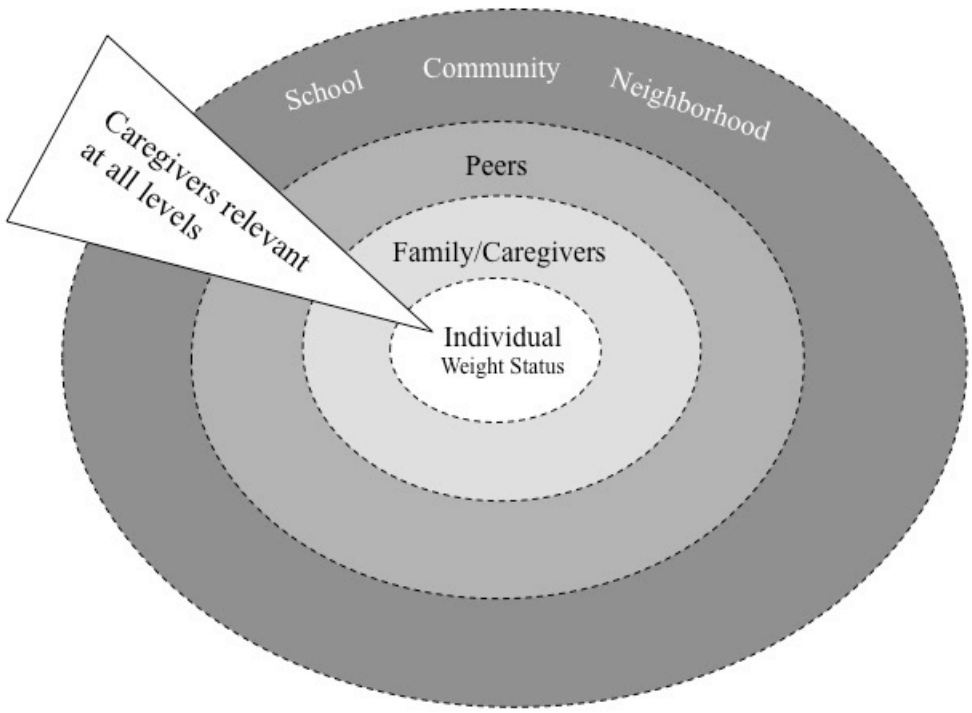
Table 5

Regression Predicting Change in Calories at Home by Perceived Built Environment

Variables	B	Standardized Beta	t	p-value
Residential Density	.000	.038	.437	.663
Land Use Mix Diversity	-.032	-.126	-1.532	.129
Land Use Access	.052	.188	2.044	**.044**
Street Connectivity	-.016	-.057	-.570	.570
Safety for Walking	.043	.127	1.311	.193
Aesthetics	-.049	-.132	-1.413	.161
Traffic Hazards	-.075	-.146	-1.628	.107
Crime	.023	.068	.778	.439
Parking	-.044	-.154	-1.737	.086
Cul-de-sacs	-.044	-.190	-2.269	**.026**
Hilliness	-.046	-.158	-1.765	.081
Physical Barriers	.035	.116	1.288	.201

- Controlling for change in total kilocalories consumed, baseline calories consumed at home, site, SES, child race and gender.

Figure 1: Socioenvironmental Model



Appendices

Appendix A

Description of Objective Environmental Variables

Variable	Description
Included in EFA	
Count Supermarkets	Number of supermarkets
Count Convenience and General Store	Number of convenience and general stores
Count Chain Quick Service	Number of chain quick service food outlets
Count All Restaurants	Number of restaurants (all types)
Count Healthy Food Outlet	Number of healthy retail food outlets
Count Unhealthy Food Outlets	Number of unhealthy retail food outlets
Household Density	Number of households per area
Percent Commercial	Percent of area that is commercial land use
Employment Density	Employment density using focal stats
Effective Walking Area	Ratio of network domain area to Euclidean buffer area
Count Parks	Number of total parks
Count Amenities	Number of types of amenities in parks
Count Private Amenities	Number of private physical activity facilities
Count Public Amenities	Number of public/non-profit physical activity facilities
Count Schools	Number of schools
Percentage of Population Below Poverty	Percent of population below poverty (census tract)
Concentrated Neighborhood Disadvantage	Neighborhood concentrated disadvantage (census tract)
Use as Individual Predictors	
Presence of 40MPH Roads	Used as a proxy for traffic speed
Street Type	Types of streets in neighborhood
Park Acreage	Area of parks intersected by buffers (acres)
Distance to park (miles)	Distance to park (miles)
Distance to school (miles)	Distance to school (miles)
Parcel Area (acre)	Area of parcel of residence (acre)
Percent Residential	Percent of area that is residential land use (sq. ft.)

Appendix B

Description of Perceived Environmental Variables

Variable	Description
Subscales	
Residential Density	Density of different housing types in neighborhood (e.g., detached single family residences, apartments, row houses)
Land Use Mix Diversity	Mean walking distance to different neighborhood facilities (e.g., physical activity, retail food outlet, other retail, bank, school, etc.)
Land Use Access	Whether facilities (stores, transit, etc.) are within easy walking distance
Street Connectivity	Small distance between intersections, multiple routes to take when walking
Safety for Walking	Infrastructure (sidewalks, crosswalks, pedestrian signals), and safety (well lit, easy visibility, separation from traffic) to facilitate walking
Aesthetics	Trees, interesting and attractive natural sights, buildings, and homes.
Traffic Hazards	Traffic density and speed
Crime	Crime rate and safety (day and night)
Individual Items	
Parking	Ease of parking in shopping areas
Cul-de-sacs	Many cul-de-sacs in neighborhood
Hilliness	Hills that make walking difficult
Physical Barriers	Barriers (e.g., freeways, railway lines, rivers) that make walking difficult