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Does the Built Environment Relate to the Metabolic Syndrome in Adolescents?

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Abstract

This article examines the influence of the neighborhood environment on blood profiles, percent body fat, blood pressure and the metabolic syndrome (MetS) in adolescents. One hundred eighty-eight adolescents (10–16 yrs) agreed to have a fasting blood sample drawn in addition to measures of weight, height, percent fat and blood pressure. A MetS cluster score was derived by calculating the sum of the sample-specific z-scores from the percent body fat, fasting glucose, high density lipoprotein cholesterol (negative), triglyceride, and systolic blood pressure. Geographic Information Systems (GIS) technology was used to calculate the distance to and density of built environmental features. Spearman correlation was used to identify significant ($p<0.05$) relationships between the built environment and the MetS. Statistically significant correlations were added to linear regression models, adjusted for pubertal status, age and sex. Multivariate linear regression models revealed significant associations between an increased distance to convenience stores and the MetS. The results of this study suggest a role for the built environment in the development of the MetS.

Introduction

The Metabolic Syndrome (MetS) is a recognizable cluster of risk factors (i.e., hypertension, dyslipidemia, obesity, and hyperglycemia) that have been associated with the development of both cardiovascular disease (ATP III, 2001) and type 2 diabetes (Grundy et al., 2005). There is no single cause in the development of the MetS; but instead a concert of underlying risk factors (i.e., abdominal obesity, aging, genetics, ethnicity, etc.) are thought to play a role in the development of the MetS (Grundy et al., 2005). Although each of these risk factors are thought to have a role in the development of the MetS, obesity and physical inactivity are considered the driving factors behind the MetS (Park et al., 2003).

Obesity is influenced by both genetic as well as behavioral factors (Weinsier et al., 1998; Hill and Peters, 1998); however recent research indicates the built environment affects behavior

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and could contribute to the development of obesity (Saelens BE, Sallis JF, Frank LD, 2003; Frank et al., 2007). The built environment consists of both the micro-environment (i.e., neighborhood and street-level characteristics) and macroenvironment (i.e., level of urbanization, land-use patterns, etc.) (Swinburn et al., 1999) and can shape opportunities for physical activity and food intake (Humpel et al., 2002). As an example of the documented association between the built environment and obesity, it has been reported that rural adults have a higher prevalence of obesity and physical inactivity than urban adults (Giles-Corti et al., 2003; Parks et al., 2003; Patterson et al., 2004; Centers for Disease Control and Prevention 1998) due to the reduced opportunities for physical activity in their neighborhood landscape.

There is less research on the impact of the built environment on adolescent obesity and physical inactivity. Some researchers have reported increased levels of physical activity among adolescents who have access to more recreational facilities or parks in the neighborhood (Cohen, Ashwood et al., 2006; Gordon-Larsen, Nelson et al., 2006; Jago et al., 2006). In addition, proximity to fast food restaurants is related to increased body mass index (BMI) and a high fat diet (Jeffery, Baxter et al., 2006) in adults, but the data on correlations of intake patterns and proximity to other food sources (grocery stores, convenience stores) are sparse for adolescents.

If the built environment is related to health outcomes such as obesity, it is reasonable to expect that biological markers related to obesity may also be impacted by environmental influences. However, the role of the built environment on biological makers of metabolic or cardiovascular diseases has yet to be examined, particularly in adolescents. Therefore, the purpose of this study is to examine the effect of the built environment on biological markers for cardiovascular and metabolic disease risk factors in adolescents. We hypothesize that proximity to healthy food sources and physical activity resources will be negatively related to the MetS. Secondarily, we hypothesize that the associate will differ between females and males since physical activity and diet patterns differ between adolescent girls and boys. The use of biological markers is novel and reduces the amount of measurement error implicit in self-report and behavioral data. Our approach is innovative as it is one of the first tests of the most distal aspects of an ecological approach examining the relationship between the built environmental and biological markers (Sallis and Owen, 1996).

Materials and Methods

Participants

Participants in this study were adolescents (ages 10–16 at baseline) enrolled in the Transdisciplinary Research on Energetics and Cancer – Identifying Determinants of Eating and Activity (TREC-IDEA) study. TREC-IDEA is a 3-year longitudinal etiologic study aimed at understanding the social and environmental influences on unhealthy weight gain in adolescences (Lytle under review). Youth were recruited from a preexisting cohort (Widome, Forster et al., 2007), a permit application listing from the Minnesota Department of Motor Vehicles, and a convenience sample from the St. Paul-Minneapolis metropolitan area. Student and parent dyads made up the TREC-IDEA cohort; funds from a TREC-IDEA development project allowed for an optional blood draw. The study was approved by the University of Minnesota Institutional Review Board.

Measurements

Participants were given a T-shirt and a pair of shorts to wear during the measurement of height, weight and percent body fat. Body mass and total body fat were determined using a digital bioelectrical impedance scale (Tanita TBF-300A Body Composition Analyzer/Scale, Tanita

Corporation, Tokyo, Japan). Height was measured using a Shorr Height Board to the nearest 0.1 cm, while the participants stood in their bare feet.

Blood pressure was measured over the brachial artery via an automated sphygmomanometry (Critikon Dinamap 8100 Adult/Pediatric non-invasive blood pressure monitor (GE Healthcare, Piscataway, NJ) after 15 minutes of seated rest in a quiet room. Three measurements of blood pressure were made; if the three measures of systolic and diastolic blood pressure were not within 15% of each other a fourth measure was taken. Pubertal status was assessed by the self-report Pubertal Development Scale (PDS) (Petersen, Crosckett et al., 1988). The PDS is a five question summed score with good internal consistency (alpha = 0.77) and high correlation between the PDS and physician rating (0.61–0.67) (Petersen, Crosckett et al., 1988).

Fasting blood samples were obtained by venipuncture from the anticubital vein into chilled tubes containing EDTA between 6:00 and 9:00 am, after a 12-hour overnight fast at the University of Minnesota General Clinical Research Center (GCRC). Plasma was separated by centrifugation for 20 minutes at 2500 rpm and 4°C for the measurement of glucose and insulin, as well as triglycerides (TG), total cholesterol, low-density lipoproteins (LDL-C) and high-density lipoproteins (HDL-C) were assessed by standard colorimetric reflectance spectrophotometry at the Fairview Diagnostics Laboratories, Fairview-University Medical Center (Minneapolis, Minnesota), a Center for Disease Control and Prevention certified laboratory.

Geographic Information Systems (GIS) technology was used to calculate the distance to and density of pedestrian infrastructure features (e.g., transit stops), population density, land-use mix (e.g., percent land used for commercial business), street pattern (e.g., median block size), restaurants, food stores and sources of physical activity (e.g., parks) from a participant’s house. Distances and density were calculated by network and straight line route. Network refers to a route between a participant’s home and a specific feature that can be reached by someone on foot along a street network. A straight line distance refers to the straight line distance features from the participant’s home, regardless of street patterns. Densities were calculated by dividing the total number of the specific feature (i.e., parks) by the land area, excluding water. Buffer distances ranged from an 800 meter buffer to 3000 meter buffer. Additional detail on the protocol for the GIS measures can be found in (Forsyth, 2007).

Determination of Metabolic Syndrome (MetS)

The presence or absence of the MetS is typically viewed as a dichotomous variable despite the fact that the components used in defining the MetS are continuous physiological variables. In children, this “all or none” approach may be somewhat problematic since the MetS as a categorical diagnosis does not track well over time (Goodman et al., 2007). In addition, many of the current definitions of the MetS do not take into consideration differences of the magnitude and/or relative contributions of the specific components of the MetS in relation to cardiovascular risk. Therefore, in the present study, as we have done previously in children and adolescents (Kelly et al., 2008) we utilized a metabolic cluster score to determine the degree and magnitude of the MetS present in each individual. The MetS cluster score was derived by calculating the sum of the sample-specific z-scores from the following components of the MetS: percent body fat, fasting glucose, HDL-C (negative), TG, and systolic blood pressure (Kelly et al., 2008).

The independent variables in this study were built environment features related to both dietary intake (e.g. presence of convenience stores) and physical activity (e.g. distance to recreation centers) as both dietary intake and physical activity patterns influence the MetS cluster score (Park et al., 2003). Twenty-six GIS variables were theoretically identified that may relate to dietary intake and/or physical activity. A 1600 meter network path was chosen for all density variables based on the following assumptions: 1) use of features may be related to proximity, 2) youth may walk or bike to nearby features (i.e. convenience store or park) and 1600 meters is less than a 20 minute walk, and 3) youth are most likely using street networks to transport themselves or be driven by parents. The density variable used was residential density which is defined as the population per unit land area (without water), as the study location has many lakes. High residential density may represent increase walking for transportation due to easier access to destinations, and more traffic congestion (Forsyth, Oakes et al., 2007). Mixed land use reflects how much land is used for major functions, such as residential, parks, and commercial areas (Forsyth, 2007). Pedestrian infrastructure and street patterns are both reflective of ease of transportation and access to retail and physical activity amenities (Saelens, Sallis et al., 2003). These are common measures of ‘walkability’ and are typically associated with active transportation rather than leisure walking (Forsyth, Oakes et al., 2007).

Direct measures of the food environment and physical activity resources were also included. Both density of and distance to measures were included for convenience/gas stations, grocery stores, and large grocery stores. “Distance to nearest” measures reflect proximity to at least one facility and density reflects concentration or exposure. Recreational resources (i.e., parks, gym, recreation center and walking/biking trail) were all “distance to nearest” measures. Distance to nearest parks, gym, recreation center, walking/biking trail and distance to school were calculated from the participant home address. The further the distance to recreational resources, the less likely adolescents are to use them and to use active transit to access the resource.

Statistical Analysis

Using the theoretically reduced neighborhood environment features, Spearman correlation was used to determine any relationship between the feature and MetS cluster score as the GIS data were skewed. Statistically significant correlations ($p<0.05$) were individually used in multivariate linear regression, controlling for pubertal status, age and sex. Multivariate linear regression was then conducted stratified by sex, controlling for pubertal status and age. Data processing was conducted in SAS v. 9.1 [SAS Institute, Cary, North Carolina] and Spearman correlations and linear regression were conducted in Stata, v. 10.1 [Stata Corportation, Stata Statistical Software: Release 10.1. College Station, TX].

Results

Of the 349 students who completed the baseline surveys, only 188 opted for the optional blood draw (Table 1). There were no statistical ($p<0.05$) differences in pubertal status, gender, age or BMI between those who opted for the blood draw (n=188) and those who opted-out of the blood draw (n=161). Table 1 describes the characteristics of the study sample overall and stratified by sex. The average age was 15.4 yrs and was comprised of 97 females and 91 males. The average body mass index (BMI) for the total sample was 21.6 kg/m^2 and percent body fat was 20.2%. The average MetS cluster score was −0.45. As expected, females were further along the developmental scale, were shorter and weighed less than the males. Females also had significantly greater proportion of body fat, total cholesterol, HDL-C, LDL-C, insulin and MetS cluster scores than males. Only systolic blood pressure was lower in females than males (Table 1).

Table 2 lists the environmental features examined and Spearman correlation coefficient with the MetS cluster score and individual component parts of the MetS cluster score, bolded for p-values less than 0.10, starred for p-values less than 0.05. Of the twenty-six environmental features, only the distance to convenience/ gas stations was significantly (rho = −0.1634, p=0.03) related to the MetS cluster score. These data would suggest that as the distance to convenience/ gas stations increases, the MetS cluster score decreases. The percent land use dedicated to parks was negatively associated with the MetS cluster score with a rho = −0.1320 although not statistically significant (p=0.07).

Percent body fat was significantly and inversely related to the distance to fast food (rho= −0.1447, p=0.05) but positively related to the density of small (rho=0.1699, p=0.02) and large grocery stores (rho=0.2305, p=0.002) within a 1600m network. In other words, as distance to fast food increased the percent body fat decreased and as the density of both small and large grocery stores increased in a 1600m network so did the percent body fat. In addition, HDL-C, was positively related to distance to convenience stores (rho=0.1562; p=0.0.03) and a positive trend was seen between HDL-C and proportion of vacant land. Systolic blood pressure was significantly and inversely related to density of transit (rho=0.1861 p=0.0.01) and there was a negative trend seen between systolic blood pressure and density of large grocery stores.

Multivariate linear regression revealed a statistically significant negative association between distance to convenience/gas stations and the MetS cluster score after controlling for puberty, age and sex (Table 3). Therefore, after accounting for individual characteristics, as the distance to convenience/gas stations increases, the MetS cluster score decreases. Conducting exploratory analysis of the marginally significant correlation of percent land use as parks found no significant association in multivariate regression after adjusting for puberty, age and sex. Multivariate linear regression models were stratified by sex, revealing a gender difference between the association of the built environment and the MetS cluster score. Males showed no significant association, yet females had a negative association between the MetS cluster score and the distance to convenience stores increased (β= −0.0003, p=0.05).

We also ran multivariate linear regression on the statistically significant components of MetS and the built environment (data not shown). After controlling for puberty, age and sex, we found no statistically significant relationships between distance to fast food restaurants, and density of small and large grocery stores and percent body fat. Similarly, the association between HDL-C and distance to convenience gas stations is attenuated to null when controlling for age, gender and pubertal status. Systolic blood pressure remained statistically significant with the density of transit (β= −22.53, SE=8.95, p=0.01) after adjustment, suggesting that as the density of public transit decreases, systolic blood pressure increases in adolescents. The association was more pronounced in boys than girls, although the interaction was not significant.

Discussion

The purpose of this study was to examine how the built environment impacts the MetS as well as individual biological markers and if any association differs by sex. Although others have attempted to examine the effect of the built environment on health (de Vries et al., 2003; Maas et al., 2006) to our knowledge this is the first study to utilize biological measures as an indicator of health or disease.

Although the MetS may be considered an adult disease, Cook et al. (2003) has reported that 4.2% of adolescents aged 12 to 19 years from the Third National Health and Nutrition Examination Survey (1998–1994) had the MetS, using a modified version of the adult criteria as defined by National Cholesterol Education Program (Adult Treatment Panel III). The MetS is growing in adolescents not only in the United States, but throughout the industrialized nations of the world (Cook et al., 2003; Duncan et al., 2004). The long term implications are considerable as industrial nations face rising rates of cardiovascular disease and Type 2 diabetes mellitus in both adults and adolescents. The relationship between chronic disease and the component parts of the MetS, including percent body fat, HDL-C, and systolic blood pressure are also well established (ATP III, 2001; Grundy et al., 2005; Grundy, 2007). We included a multivariate analysis for component parts of the MetS that showed statistically significant correlations with built environment features.

While the built environment and biological markers are quite distal in the causal pathway, we did observe a significant relationship between the distance to convenience stores and the MetS cluster score after adjusting for pubertal status, age and gender. As the distance to convenience stores increased, the MetS cluster score decreased, suggesting that the greater distance a child or adolescent is from a convenience store the lower the development of the MetS. Most studies to date have examined the relationship between distance to food outlets in regards to driving distance or driving times and level of obesity (Frank et al., 2007; Nielsen and Hansen, 2007). These studies have produced conflicting results at best with some studies showing a relationship between obesity levels and distance to food outlets (Frank et al., 2004; Lopez-Zetina et al., 2006) while others have shown no relationship (Liu, Cunningham et al., 2002; Kelly-Schwartz, Stockard et al., 2004; Burdette and Whitaker, 2004; Ewing, Brownson et al., 2006). Some of the difference between these studies may be attributed to the age of the population studied. In the present study our population was largely between the ages of 10 and 16 years; 48 boys and 44 girls were age-eligible to drive but we do not have information on driving status of the sample. Therefore, greater distances from convenience stores may prevent the participants in the present study from walking to or riding their bicycle to convenience stores to purchase a “snack” or beverage. Our stratified analysis revealed that the negative association was seen only in girls, and not in boys. While the rationale for this difference is not testable with our data set, it may be that transit patterns are different in adolescent males as compared to females. Males may be driving at an earlier age or have access to older friends that drive, making the distance network between home and convenience stores less relevant to their behavioral choices. Safety may also be an issue with females less likely to feel comfortable walking or biking in their neighborhoods as compared to males.

There was also a trend for a relationship between the percent land use dedicated to parks and the MetS cluster score. Although not statistically significant the trend for significance was in the right direction and would suggest that greater access to parks and lower density of retail food outlets lowers the risk of developing the MetS. These results are in agreement with those reported by Nielsen and Hansen (Nielsen and Hansen, 2007) who reported that Danish individuals (age 18–25 yrs) who had access to green areas were less likely to be overweight/obese. Among adolescent girls from five cities in the U.S., Cohen et al (2006) found that proximity to parks was associated with increased moderate and vigorous physical activity (Cohen et al., 2006). Jago et al. (2006) also reported that access to parks was associated with physical activity levels of male adolescents but the relationships differed by the type of park and the coding approach. The presence of a community park within a 400 m radius of a subject’s home was negatively associated with sedentary behavior and positively associated with light intensity physical activity. However, when a 1-mile buffer was used there were no significant relationships between access to parks and physical activity (Jago et al., 2006). Taken together these data would suggest access to public parks and recreation areas may result in a residential environment that encourages physical activity, which may result in fewer individuals in that area being overweight or obese as both obesity and physical inactivity are thought to be driving factors in the development of the MetS (Park et al., 2003).

Percent body fat, HDL-C and SBP each showed significant correlations and trends in the right direction with several built environment features. However, in this sample, only the inverse association between SBP and density of transit stops remained significant in the multivariate analysis. A possible explanation for this relationship may be that as public transit options decrease, reliance on driving to destinations increases, reducing activity. Again, we are not able to test this hypothesis with our data.

There are some limitations to this study. First, the outcome of MetS is quite distal from the exposure and, while obesity and physical inactivity (Parks et al., 2003) have been shown to affect MetS, this study does not explore mediating factors. The significant associations between the MetS cluster score, SBP and the built environment may not reflect actual behavior (e.g., eating high fat foods, sedentary behavior), but may be due to other factors, such as the quality of home or school food environment, or socioeconomic variations. In addition, while our research question was based on an ecological theory and current scientific thought that the built environment affects population health, we acknowledge that the results that we report may be chance findings. At the bi-variate level we examined 156 possible relationships, and found only nine that were significant at a p-value of at least 0.10. Bonferroni adjustment for the number of associations tested further reduced the number of likely statistically significant associations.

GIS data also have limitations. Although GIS data can assess the nutrition and physical activity environment, it does not account for consumer behavior or quality of facilities or neighborhood features, such as sidewalk conditions (Forsyth, Lytle, in review). Another unresolved methodological concern with GIS data is the ambiguity in determining the appropriate buffer distance that is relevant for adolescents (Forsyth, Lytle, in review). Continued refinement of GIS methodological obstacles and theory is needed to continue to advance research in this area.

Finally, another limitation of this study may be in the actual definition of the MetS. In the present study we used percent fat instead of BMI percentile due to the fact that BMI percentile is a less sensitive indicator of fatness in children (Reilly et al., 2000). We replaced percent fat with BMI percentile in our MetS cluster score and the relationship between the MetS cluster score and the distance to convenience stores remained significant (rho=−0.1717, p=0.02), suggesting that the MetS cluster score is robust.

Conclusion

Although this study examines the most distal associations between the build environment and biomarkers, with no attention to mediating factors, our results suggest a role for the built environment on the development of disease in adolescents. Additional research on biological and physiological components and the built environment with larger and more generalizable samples is necessary to determine the role of the build environment on disease incidence and progression. In addition, further investigative work is needed to understand the differential relationship observed by sex.

Our ability to find statistically significant relationships between the built environment and the MetS and some of its component parts after adjustment for potential confounders may represent chance findings. However, if an ecological theory continues to be embraced by the scientific community, research needs to be conducted that examines points of association along a continuum of proximal and distal environmental factors that may influence health. This research demonstrates a process, using state of the science assessment tools, to examine two points that are most distal from each other.

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Table 1

Study sample description by gender, TREC IDEA, 2006–2007

Variable	Total (n=188)		Males (n=91)		Females (n=97)		T	p
	Mean	S.E.	Mean	S.E.	Mean	S.E.		
Age (yrs)	15.44	1.67	15.56	1.57	15.32	1.75	10.2	0.31
Puberty	15.24	3.29	13.64	2.95	16.74	2.87	−7.31	<0.01
Height (cm)	168.19	0.71	172.92	1.07	163.75	0.68	7.30	<0.01
Weight (kg)	61.59	1.06	65.13	1.71	58.27	1.19	3.33	<0.01
Body Mass Index (kg/m^2)	21.59	3.83	21.52	3.87	21.67	3.80	−0.27	0.79
Percent Body Fat (%)	20.17	9.65	13.79	7.53	26.15	7.33	−11.40	<0.01
Diastolic Blood Pressure (mmHg)	54.41	0.54	53.94	0.69	54.85	0.82	−0.84	0.40
Systolic Blood Pressure (mmHg)	115.00	9.21	117.26	9.53	112.88	8.41	3.35	<0.01
Triglycerides (mmol/L)	0.89	0.40	0.84	0.34	0.94	0.43	−1.89	0.06
Total Lipoprotein Cholesterol (mmol/L)	3.86	0.06	3.64	0.07	4.06	0.08	−3.86	<0.01
High-Density Lipoprotein Cholesterol (mmol/L)	1.27	0.29	1.20	0.31	1.33	0.27	−3.20	<0.01
Low-Density Lipoprotein Cholesterol (mmol/L)	2.18	0.04	2.00	0.06	2.30	0.07	−2.59	0.01
Insulin (pmol/L)	60.07	37.78	51.81	30.77	67.92	42.09	−2.98	<0.01
Glucose (mmol/L)	4.48	0.02	4.52	0.03	4.43	0.04	1.75	0.08
Metabolic score	−0.45	3.22	−1.40	3.13	0.44	3.07	−4.07	<0.01

Table 2

Theoretically reduced GIS variables and Spearman correlation coefficients with Metabolic Syndrome, Twin Cities, 2007

Description	**Environmental features (n=26)**	**Metabolic Syndrome (n=188)**	**Percent Body Fat**	**Insulin**	**HDL**	**Triglycerides**	**Systolic Blood Pressure**
Density	Residential Density, 1600m network	0.1016	0.0996	−0.0022	−0.081	−0.0724	−0.0401
Pedestrian Infrastructure	Distance to Transit	−0.0457	−0.0573	0.0562	0.0381	0.0752	0.1135
	Density of Transit, 1600m network	0.0172	0.0581	−0.0636	−0.006	−0.0815	−0.1861[*]
Land Use Mix	Employment Density, 1600m network	0.0776	0.0761	−0.0231	−0.1117	−0.0654	−0.0409
	Percent Land Use –residential	0.0749	0.0376	0.0046	−0.0176	−0.0147	−0.0497
	Percent Land Use –park and recreation	**−0.1320**	−0.0549	**−0.1351**	0.0738	−0.0941	−0.0379
	Percent Land Use –vacant	−0.0804	−0.0129	0.0511	**0.1233**	0.0187	0.0439
Street Pattern	Median block size, 1600m network	−0.0338	−0.0798	0.0782	−0.0158	0.0946	0.0178
	Number of access points, 1600m network	0.1160	0.1188	−0.026	−0.1016	−0.0058	−0.051
	Intersection density, 1600m network	0.0953	0.0828	−0.0018	−0.0115	−0.0742	−0.0761
Restaurants	Distance to Fast Food	0.0921	**−0.1447**[*]	−0.0211	0.0649	0.0163	0.0691
	Density of Fast Food, 1600m network	0.0343	0.0808	−0.0574	−0.0595	0.0025	−0.0894
	Distance to Non Fast Food	−0.0774	−0.014	0.0037	0.0872	0.0967	0.0202
	Density of Non Fast Food, 1600m network	0.0872	0.0122	0.0126	−0.116	−0.0125	0.0035
Food Stores	Distance to grocery stores	−0.0676	−0.0702	−0.0173	0.095	0.0504	0.0911
	Density grocery stores, 1600m network	0.1011	**0.1699**[*]	0.0005	−0.0378	−0.0436	−0.104
	Distance to large grocery	−0.1103	−0.1157	0.0395	0.0769	0.03	0.0584
	Density large grocery, 1600m network	0.1098	**0.2305**[*]	0.0164	0.0451	−0.0151	**−0.1349**
	Distance to convenience/gas	**−0.1634**[*]	−0.0969	−0.0479	**0.1562**[*]	−0.065	−0.0376
	Density convenience/gas, 1600m network	0.1028	0.0866	−0.0065	−0.1084	0.035	0.093
	Busy streets, 1600m network	−0.0608	−0.0888	−0.0336	−0.1112	0.0845	0.0011
	Distance to parks	0.0164	0.0525	0.0124	−0.1027	0.0058	0.0708
Physical Activity	Distance to gym	−0.0330	−0.0221	−0.0224	0.046	−0.053	0.0567
	Distance to recreation center	−0.0185	−0.0136	0.0365	0.0478	0.0117	−0.0004
	Distance to walking/biking trail	−0.0501	−0.0765	0.1186	−0.0142	0.0638	−0.0531
	Distance to School	0.0196	0.0402	0.0359	0.0264	0.0027	0.0102

Bolded items represent associations at $p \leq 0.10$

[*] Statistically significant at $p \leq 0.05$

Table 3

Multivariate linear regression models of theoretically reduced built environment features, food and physical activity destination and metabolic syndrome for total sample and by sex, Twin Cities, 2007.

	Total*		**Males** (n=91)**		**Females** (n=97)**	
Feature	**Coefficient (SE)**	**P**	**Coefficient (SE)**	**P**	**Coefficient (SE)**	**P**
Distance to convenience/ gas station network	−0.0002 (0.0001)	0.04	−0.0001 (0.0001)	0.41	−0.0003 (0.0001)	0.05

* adjusted for pubertal status, age and sex

** adjusted for pubertal status and age