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Active design in affordable housing: A public health nudge

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ABSTRACT

This pilot study investigates the impact of active design (AD) strategies on physical activity (PA) among adults living in two Leadership in Energy and Environmental Design (LEED) certified affordable housing developments in the South Bronx, New York. One building incorporates LEED Innovation in Design (ID) Credit: Design for Health through Increased Physical Activity. Tenants in an affordable housing building (AH) incorporating active design strategies completed PA self-assessments at their lease signing and one year later in 2015. Trained research assistants obtained body measurements. Residents of neighboring non-AD affordable housing (MCV) served as a comparison. Thirty four adults were recruited from AH and 29 from MCV, retention was 56% (n = 19) and 52% (n = 15) respectively at one year. The two groups' body mass index (BMI) and high-risk waist-to-hip ratio (WHR) were not statistically significantly different when analyzed as continuous variables, although BMI category had a greater decline at AH than at MCV ($p = 0.054$). There was a 31.5% increase in AH participants meeting MPA requirements and a statistically significant improvement in females ($p = 0.031$); while there was no change in the MCV participants overall or when stratified by gender. AH participants were significantly more likely to have reported increased stair use and less likely to have reported no change or decreased stair use than participants from MCV participants ($p = 0.033$). Housing has a role in individual health outcomes and behavior change, broad adoption of active design strategies in affordable housing is warranted to improve physical activity measures.

1. Introduction

Regular physical activity (PA) is associated with optimal health, decreased cardiovascular disease (CVD) and comorbidities, and reduced risk of mortality (Samitz et al., 2011; Sattelmair et al., 2011). To heighten public awareness of the need for increased PA and to subsequently decrease rates of obesity, the U.S. Department of Health and Human Services issued the Physical Activity Guidelines for Americans in 2008 (Office of Disease Prevention and Health Promotion, 2008). The guidelines as set forth by the Centers for Disease Control (CDC), recommend that adults 18–65 years of age engage in 150 min of moderate-intensity physical activity (MPA) or 75 min of vigorous physical activity (VPA) per week and two days per week of strength training to reduce risk of disease and promote a healthy lifestyle (Centers for Disease Control and Prevention, 2015a). These lifestyle changes have shown to improve mental health, help control weight, and decrease the risk for chronic medical conditions such as type 2 diabetes, metabolic syndrome, and CVD. Research findings suggest that PA may decrease the risk for breast, endometrial, colon and lung cancers (Centers for Disease Control and Prevention, 2015b; Dethlefsen et al., 2017; Wolin et al., 2009). However, there is a national trend towards increasing sedentary behavior due in part to lack of resources and available outlets for exercise, work environments that encourage seated-static positions, and the availability of technologies such as entertainment systems and computers (Owen et al., 2011; Barwais and Cuddihy, 2015; Parry and Straker, 2013). A recent study showed that adults spend approximately 50–60% of their day engaged in activities that require low-intensity movement whether at home, work, or school (Wolin et al., 2009).

Efforts to increase PA among Americans have been largely unsuccessful. Only 20% of adults living in the U.S. met both the aerobic and muscle strengthening national recommendations (Centers for Disease Control and Prevention, 2011). The introduction of small amounts of PA in the daily routines of Americans may be an effective strategy in increasing health benefits (Centers for Disease Control and

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Prevention, 2015b).

Recent evidence suggests that the built environment and structural design strategies can impact human behavior and promote health (Barnett et al., 2017; Suminski et al., 2006). The built environment is a multifaceted concept that includes land use, active transportation systems, community design in its built and natural form; and patterns of human activity within the physical environment (Boarnet et al., 2002). Studies on barriers to PA within the built environment include poor neighborhood walkability, perceptions of neighborhood safety, lack of playgrounds or access to recreational facilities, and neighborhood planning that encourages automobile, rather than walking or bicycle use (Suminski et al., 2006). In response, urban planners, architects and interior designers have created active design initiatives to promote PA and create healthy, livable communities in welcoming, safe environments (Garland et al., 2014).

Regular stair use has been associated with enhanced health, increased strength and fitness, weight loss and reduced risk for osteoporosis and CVD (Kerr et al., 2001). Active design (AD) strategies such as delayed speed elevators and motivational signs or point-of-decision prompts in combination with stairwell enhancements, encourage stair use and decrease the likelihood of people choosing elevators or escalators (Task Force on Community Preventive Services, 2010; Boutelle et al., 2001). These design elements are used to change an individual's knowledge and attitudes about stairs use and the overall value of PA (Soler et al., 2010).

The use of AD strategies in the built environment is a means of promoting PA (Boarnet et al., 2002). Few studies have evaluated the correlation between AD and increased PA in affordable housing. In an effort to promote health in New York City (NYC) residents, in 2000 the NYC Department of Health and Mental Hygiene collaborated with NYC Department of Design and Construction as well as the Mayor's Office of Management and Budget to develop a Leadership in Energy and Environmental Design (LEED) Innovation in Design (ID) Credit: Design for Health Through Increased Physical Activity (Lee, 2012). This pilot study investigates the impact of AD strategies on PA among adults living in two LEED-certified affordable housing developments in the South Bronx; one of which incorporates the LEED ID credit.

2. Methods

2.1. Study site

Arbor House (AH) and Melrose Commons V (MCV) are platinum LEED-certified affordable housing buildings in the South Bronx occupied in May 2010 and February 2013, respectively. Both residences were constructed by the same developers with nearly identical unit layouts. AH, an eight-story, 124-unit building, served as the intervention site. It earned the LEED ID credit by including features such as delayed elevator speed and non-prominent location of elevators, an indoor gym and outdoor exercise circuit. It includes central stairwell placements which are wide, well-lit, with music playing and visible artwork, along with point-of-decision prompts encouraging their use. MCV, a five-story, 63-unit building served as the control, without any LEED ID credit features.

2.2. Participant recruitment

A lottery to allocate housing in AH was performed in June 2012 by the NYC Department of Housing Preservation and Development. The lottery process was publicized to the community via newspapers, internet, and telephone housing hotlines. Eligibility criteria for the lottery were based on proof of NYC residence and an income level below 60% of the median income for that year in that neighborhood. Both buildings are located in the same neighborhood of the South Bronx. In 2014, 39% of residents lived below the Federal Poverty Level with a median income of $27,209 (United States Census Bureau, 2017). Current neighborhood residents were given priority. Housing in MCV was allocated in late 2009 with the same methodology and eligibility criteria.

The pilot study was conducted using convenience sampling of consenting adult residents of AH and MCV. Researchers were provided with the AH lease signing schedule, beginning in March of 2013. Prospective study participants were approached after their lease signing by trained research assistants (RA) who introduced the study and obtained written consent. Those interested but lacked time were provided alternative dates. RAs recruited control group subjects in the MCV lobby and via fliers. The study was conducted during weekday business hours, evenings, and weekends. In both buildings, up to two adults per household were consented. Follow-up was conducted 12 to 15 months following initial recruitment. Study participants were contacted at least three times via email, phone, and/or letter under the door to repeat data collection before considering them lost to follow-up.

Inclusion criteria included being over 18 years of age and English-speaking. Participants did not have to be lease signers themselves but needed to reside in the unit. Exclusion criteria included having a physical disability that precluded stair use (i.e. wheelchair use or use of walking aids). Sociodemographic information such as age, gender, and smoking status were collected. Non-participation did not affect housing eligibility. Recruitment in AH continued up to one month after occupancy. Recruitment at MCV was held simultaneously, to reduce impact of seasonality. All participants provided informed consent and the Institutional Review Board of the Icahn School of Medicine at Mount Sinai approved this study. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

2.3. Data collection

Height, weight, waist and hip circumference were measured to calculate body mass index (BMI), as kg/m^2, and waist-to-hip ratio (WHR), using the World Health Organization data gathering protocol on WHR. Waist circumference measurement was made at the approximate midpoint between the lower margin of the last palpable rib and the top of the iliac crest. The hip circumference measurement was taken around the widest portion of the buttocks. All measurements were taken two times and averaged (World Health Organization, 2011). Each individual was categorized for BMI as 'normal' (18.5–24.9), 'overweight' (25–29.9), or 'obese' (≥ 30); and for WHR as being at "low" (< 0.95 for males and < 0.80 for females), "moderate" (0.96–1.0 for males and 0.81–0.85 for females) or "high" risk (> 1.0 for males and > 0.85 for females) (World Health Organization, 2011; Centers for Disease Control and Prevention, 2016).

Questionnaires were administered by the RA at the time of study enrollment (T_0) and 12–15 months later (T_1). Frequency and intensity of PA were determined using the Physical Activity Questionnaire© which consisted of 11 validated questions derived from the Block Dietary Data Systems. The questionnaire utilized the Compendium Coding Scheme which categorizes each specific activity as MPA or VPA based on energy expenditure (Ainsworth et al., 2011). Four questions were added by the research team to further measure stair use both inside and outside the home. Each individual was classified as having reported less stair use at T_1 than at T_0 ("decline"), the same stair use at both time points ("no change") or more stair use at T_1 than at T_0 ("increase"). The Brief Food Questionnaire© was administered to calculate food frequencies on usual eating habits in the past year. Study participants received $40 cash as incentives at both data collection points.

2.4. Statistical analyses

IBM SPSS statistical software Version 22.0 (SPSS, INC., Chicago, IL) was used for data analysis. Descriptive statistics were produced for all study variables, stratified by site (AH or MCV). Baseline comparisons of

Table 1
Participant baseline characteristics 2013–2015, Bronx, NY.

Characteristics	Arbor House n (%)	Melrose n (%)	p-Value
Gender			
Females	16 (84.2)	10 (66.7)	0.42
Males	3 (15.8)	5 (33.3)	
Age	29.1 (± 6.9)	37.0 (± 11.0)	0.02*
BMI	34.3 (± 8.2)	31.7 (± 6.6)	0.33
WHR	0.85 ± 0.076	0.83 ± 0.083	0.43
Met MPA	4 (21.1)	9 (60.0)	0.02*
Met VPA	9 (47.4)	7 (46.7)	0.97
Current smoker	0 (0)	0 (0)	–

For continuous variables n ( ) = mean (± SD)
* Statistical significance of $p < 0.05$.

participant characteristics between the two sites were made using a *t*-test for two independent samples (for age) and Fisher's exact test (for gender). The degree of change from T_0 to T_1 within a study site was assessed using paired *t*-tests for continuous variables (BMI, WHR) and McNemar's test for categorical variables (stair usage, BMI category, meeting MPA and VPA guidelines). The extent to which the degree of change differed between the two study sites was assessed by first calculating difference scores ($T_1 - T_0$) for each subject and then comparing these between sites using a *t*-test for two independent samples (continuous variables) or chi-square test (categorical variables), as appropriate. A significance level of $\alpha = 0.05$ was used for all tests. Multivariable analyses were not attempted due to the limited sample size.

3. Results

Thirty-four AH participants and 29 MCV participants consented to the study and completed the baseline questionnaires at T_0. Nineteen of the 34 AH participants (56%) and 15 of the 29 MCV participants (52%) completed T_0 and a T_1 questionnaires and were included in final analyses (Table 1). Both groups had loss to follow up due to discontinued phone numbers, change of domicile, or pregnancy. Sixteen AH subjects were female (84%), ranging in age from 18 to 48 years with a mean age of 29.3 years. Ten of the MCV participants were female (67%), ranging in age from 18 to 49 years with a mean age of 39.2 years. There was a statistically significant difference in age between AH and MCV participants at baseline ($p = 0.02$), while there was no significant difference in gender between groups ($p = 0.42$). All participants reported being non-smokers. There was little change in dietary consumption of fruits and vegetables at AH and MCV. At T_0 26.3% of AH participants reported consuming the U.S. Department of Agriculture's recommendation of 5–7 fruits or vegetable servings a day (U.S. Department of Health and Human Services and U.S. Department of Agriculture., 2015). Both groups were economically comparable based on median income for that particular neighborhood.

3.1. Body anthropometric measurements

The distribution of BMI and WHR across participants in AH and MCV are found in Table 2. When treated as a continuous variable there was no change in mean BMI or WHR within group (AH: $p = 0.658$; MCV: $p = 0.955$), or when compared to each other ($p = 0.811$) from T_0 to T_1. BMI category change (defined as moving between 'normal weight', 'overweight', 'obese' subgroups), had a greater decline at AH than at MCV (Fig. 1; $p = 0.054$).

3.2. PA questionnaire

There was a significant increase in stair use at AH post-occupancy (Figs. 1 and 2; $p = 0.05$). At AH there was a nearly 53% decrease from T_0 to T_1 in the number of individuals reporting not having walked up any flights of stairs per week. As seen in Table 1, the analogous percentage among those living at MCV remained constant at T_0 compared to T_1; with 33 of study participants reported no stair ascent.

Fig. 2 shows the change in stair use at home. Those at AH were statistically significantly more likely to have reported increased stair use and less likely to have reported no change or decreased stair use than those at MCV ($p = 0.033$).

As notated in Table 2, responses to the PA questionnaire indicated an overall 31.5% increase from T_0 to T_1 in the number of individuals at AH meeting the MPA requirement and no change in those meeting the VPA requirement at AH. In contrast, at MCV, there was a 21% increase in the number of those meeting the MPA requirement and no change in those meeting the weekly VPA requirement over the same time period. When stratified by gender, there was a significant improvement in the number of females at AH meeting the MPA requirement ($p = 0.031$). There was no significant difference in the number of females who met the MPA or VPA requirement in MCV at T_1 compared to T_0. However, in both AH and MCV, there was an increase by 10% in females meeting the VPA requirement over the study period (Table 3).

4. Conclusions

4.1. Anthropometric measurements

BMI is a common method used to categorize obesity, but WHR, is a better predictor of CVD risk and is a good indicator of the body's composition of visceral fat (de Koning et al., 2007). High deposition of visceral adipose fat is associated with multiple risk factors for CVD and type 2 diabetes. This association supports the use of WHR in routine physical examinations to address a person's risk for certain chronic conditions (Dobbelstyn et al., 2001). No statistically significant change was noted in mean BMI or WHR within groups or compared to each other from T_0 to T_1, but there was a greater overall decline in BMI at AH than at MCV. However, weight change is also affected by caloric intake, individual metabolic rates, hormone balance, sleep and stress levels (Centers for Disease Control and Prevention, 2015c). Health benefits are associated with increased PA regardless of change in BMI, including improved cardiovascular health and mood, reduced incidence of diabetes and stroke, and decreased brain age (Penedo and Dahn, 2005; Warburton et al., 2006).

4.2. Physical activity

The study findings suggest a modest benefit in affordable housing with LEED ID credit. PA levels increased in AH participants with a greater percentage meeting the CDC MPA and VPA guidelines. Female participants in particular, demonstrated a statistically significant difference in meeting the MPA requirement despite the small sample size. This finding is notably important; 54.1% of American women do not engage in the recommended amount of PA, a percentage that increases with age (Centers for Disease Control and Prevention, 2015a).

The incorporation of AD strategies in the built environment through the use of easily accessible, prominent, aesthetically pleasing stairwells can increase PA and improve the health of communities in underserved areas (United States Census Bureau, 2017; Nicoll, 2007; Boutelle et al., 2001; Kerr et al., 2004). However, disparities exist. The National Longitudinal Study of Adolescent Health demonstrated that low-income and minority communities were less likely to have PA facilities. Conversely, adolescents' BMI decreased as the number of such facilities increased (Gordon-Larsen et al., 2006). Parents' perceptions of the surrounding built environment, such as degree of safety, also influence children's PA (Lumeng et al., 2006). Understanding these barriers can assist the development of buildings that encourage intentional and incidental PA in communities.

Table 2
Body anthropometric measurements and average upstairs flight per week 2013–2015, South Bronx, NY.

	AH		MCV		p-Value
	n = 19		n = 15		
	T_0	T_1	T_0	T_1	
	Responses (%)	Responses (%)	Responses (%)	Responses (%)	
BMI					
Mean	34.32	34.28	31.74	31.26	0.67
Std. deviation	8.228	9.215	6.589	5.934	
Normal	1 (5.3)	1 (5.3)	3 (20.0)	2 (13.3)	
Overweight	4 (21.1)	6 (31.6)	5 (33.3)	4 (26.7)	
Obese	14 (73.7)	12 (63.2)	7 (46.7)	9 (60.0)	
WHR					
Mean	0.851	0.859	0.829	0.826	0.68
Std. deviation	0.076	0.126	0.083	0.092	
Low risk	6 (31.6)	5 (26.3)	8 (53.3)	9 (60.0)	
Moderate risk	3 (15.8)	5 (26.3)	4 (26.7)	0 (0.0)	
High risk	10 (52.6)	9 (47.4)	3 (20.0)	6 (40.0)	
STAIR USAGE (times per week)					
None	15 (78.9)	5 (26.3)	5 (33.3)	5 (33.3)	0.024*
1–2	0 (0.0)	2 (10.5)	1 (6.7)	2 (13.3)	
3–4	1 (5.3)	4 (21.1)	6 (40.0)	4 (26.7)	
5–6	2 (10.5)	3 (15.8)	3 (20.0)	4 (26.7)	
7 & greater	1 (5.3)	5 (26.3)	0 (0.0)	0 (0.0)	

* Statistical significance of $p < 0.05$.

4.3. Stair usage and prompts

After approximately one year of living in AH, residents reported a significant increase in stair use, with a 53% decrease in the number of individuals who reported not having walked up any flights of stairs per week at their previous housing. Many of the design strategies implemented at AH aimed at encouraging stair use can be associated with the behavior changes that have been noted (Boarnet et al., 2002).

Increased stair use associated with these interventions can be seen in a variety of settings, including homes, clinics, schools, and office facilities (United States Census Bureau, 2017; Lee et al., 2012). A long-term health study linking PA and stroke incidence showed that men who climbed three to five floors a day on average had a 29% reduction of their risk of stroke (Paffenbarger et al., 1986). The institution of a daily progressive stair climbing routine has been linked with improved cardiorespiratory fitness and lipid profiles of previously sedentary women as well as maintaining energy balance (Garland et al., 2014; Boreham et al., 2000). Just two minutes of stair climbing per day can burn enough calories to offset the average annual weight gain of two pounds seen in American adults (Zimring et al., 2005).

4.4. Strengths and limitations

This study has several key strengths that enrich the current literature. It is a unique pilot study that examines the impact of the LEED ID credit through increased PA in affordable housing, focusing on the built environment's role in individual health outcomes and behavior change. The methodology of this study was strengthened by the utilization of a comparison building similar in all key aspects except for the active design elements, as well as the relatively strong retention rate for a community housing project that experiences high turnover of residents within each household and within each building.

Several issues should be considered when interpreting these findings. Sampling was based off convenience, and, therefore, subject to selection bias. The mean age at MCV was significantly older, which may have independently influenced the differences noted in PA. This was a

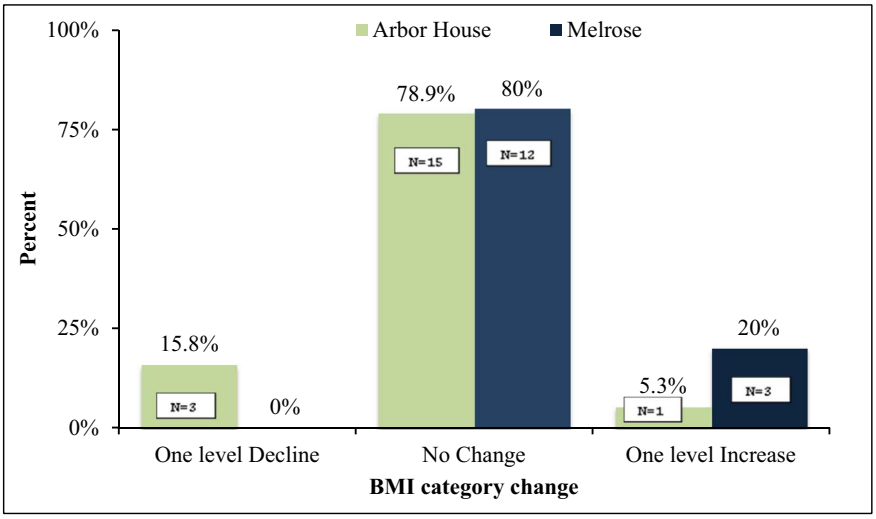

Fig. 1. Change in BMI in participants 2013–2015; South Bronx, NY.

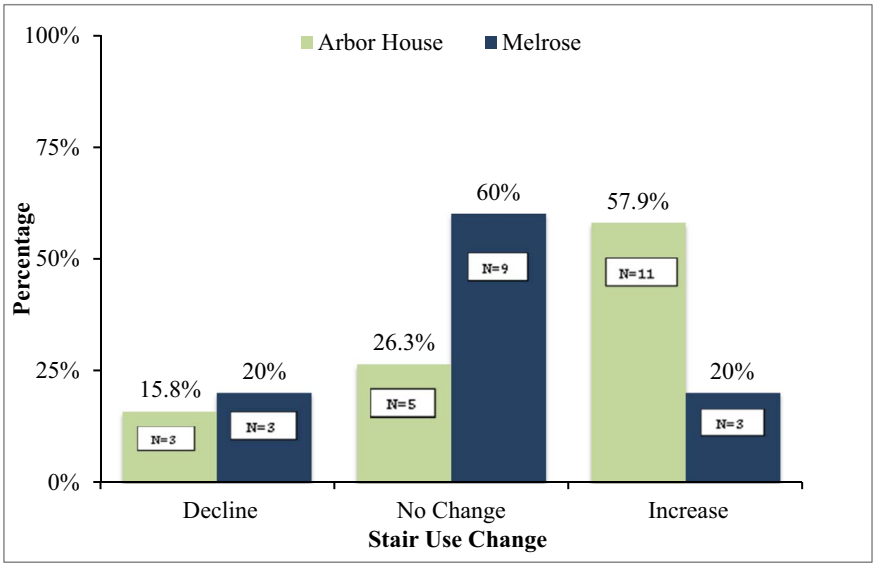

Fig. 2. Change in stair use at home: average upstairs flights per week 2013–2015, South Bronx, NY.

Table 3
Measured physical activity 2013–2015, South Bronx, NY.

	AH		MCV	
	T_0	T_1	T_0	T_1
	Responses (%)	Responses (%)	Responses (%)	Responses (%)
Total met MPA n = 19	4 (21.1)	10 (52.6)	9 (47.4)	13 (68.4)
Females met MPA n = 16	1 (6.3)	7 (43.7)*	6 (37.5)	10 (62.5)
Total met VPA n = 19	9 (60.0)	9 (60.0)	7 (46.7)	7 (46.7)
Females met VPA n = 16	5 (50.0)	6 (60.0)	4 (40.0)	5 (50.0)

* McNemar's test significant at p = 0.031.

natural experiment and the small sample size limits the statistical power to detect differences between the participants at the two residences. Some of the data collected was based on self-report, subjecting it to recall-bias and over or under reporting. Further comparison between the two groups could not be completed due to poor response rates on socio-demographic survey questions.

4.5. Public health implications

This pilot study adds to the growing body of literature on the association between PA levels and the built environment. This is the first known study specifically evaluating the benefits of LEED ID credit in affordable housing. It provides support and justification for affordable housing stakeholders to consider incorporation of AD elements and strengthens the correlation between housing and health. Future studies should not only employ objective measures of PA and the relationships between PA and health outcomes, but also attempt to have longer follow up to determine sustainability of changes (Prince et al., 2008).

Conflicts of interest

None

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