Association of built environment with physical activity and health among Chinese women living in Xi'an

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Abstract

Background: The built environment (BE) has been proved to be the factors affecting physical activity(PA) and health level of residents. The aim of this study was to analyze the association of BE with PA and health of Chinese women living in Lianhu District, Xi 'an.

Methods: A cross-sectional study was conducted among 202 Chinese women aged 15-69 years old. The International Physical Activity Questionnaire-long version (IPAQ-L) was used to evaluate PA. BE was measured by the Neighborhood Environment Walkability Scale - Abbreviated (NEWS-A). General linear regression models were created to assess the relationship among BE, PA and health related variables, including body mass index (BMI), body fat percentage (BFP), systolic blood pressure (SBP), and diastolic blood pressure(DBP). All the models were controlled for age.

Results: Transportation PA were negatively associated with residential density($P < 0.05$). No significant correlation was found between BE and leisure time PA($P > 0.05$). In the High-PA group, traffic safety was positively correlated with BFP ($P < 0.05$). In the Moderate-PA group, traffic safety was positively correlated with SP, land use mix access was negative associated with DP ($P < 0.05$). No significance was found in other aspects ($P > 0.05$).

Conclusion: The results suggest BE is related to the level of PA and health of Chinese women in living in Xi'an. Higher residential density was negatively associated with transportation PA and BMI, while traffic safety is positively correlated with BFP. The associations between BE and health were mixed in different PA groups. Further research is necessary to dig out the exact impact of BE on PA and health in this population.

Background

With the continuous progress of economic development，women are playing an increasingly important role in society. Young and middle-aged Chinese women usually take care of family and also work under considerable pressure. Studies have shown that the PA of Chinese women is insufficient. Lower level of PA will have an impact on health, which could be harmful for those women's health [1,2].

Research shows that sedentary lifestyle is one of the important reasons affecting human health[3,4]. High-level PA can effectively improve human cardiopulmonary function and reduce the incidence of chronic diseases, and the risk of cardiovascular disease is lower in active people[1,5,6]. In order to explore the related factors affecting PA and health, studies have found city BE is one of the most important reasons influencing the level of PA and health[7–9]. For example, it has been approved that a positive association existed between residential density and traffic-related walking[10]. There are also positive associations between land-use-mix and any bouts of walking/cycling for transport[11]. Some researchers have confirmed street lighting near the residence, the planning of sidewalks and vehicle ways, and other road facilities are positively related to residents' PA levels[12,13]. Additionally, public order in the community, the artificial or natural aesthetic factors of the environment, the construction of public entertainment places also have a direct or indirect impact on residents' PA[14]. The relationship between BE and PA has been confirm by studies in Brazil[15–17], the Czech

republic and Poland[18], Shanghai[19], Hangzhou[20] and some other areas using NEWS-A and IPAQ-L questionnaires, which were commonly-used international questionnaires with high reliability and validity.

Xi'an is a historic city with many ancient architectural sites. The Lianhu District is the center of Xi'an, and there are many historic sites in the area. Some buildings in the area are protected by the cultural relics of the city, and are different from other modern cities. Therefore, it is necessary to analyze the association of BE with residents' PA and health level in Lianhu District of Xi 'an. We investigated BE in Lianhu District, PA and BMI, BFP, and BP of women aged 15–69 years, and explore the association of BE with PA and health level. We hypothesized that there was a positive correlation between BE and residents' PA. Moreover, there was a negative correlation between BE and BMI, BPF and BP of Chinese women with different levels of PA. Our analyses provide empirical experience for cities similar to Xi 'an, an ancient capital in China, and establish relevant theoretical model to enrich the research in this field.

Methods

Sample and Study Design

Lianhu District was selected as the main research area for our study. In total, 202 residents in Lianhu District participated our study and completed questionnaires and health tests. Participants in this study were those aged between 15 and 69 years old, with normal reading and speech abilities, and no cognitive impairment diagnosed by doctors. The average age of participants was 46.6± 13.8 years old. All participants in this study have signed written consents to participate. The study was approved by the ethics committee of Shaanxi Normal University.

Study Procedure

Participants were asked to fill a structured questionnaire of their individual characteristics, including name, sex, age, address, employment, history of chronic disease, family income, etc. Secondly, the Chinese version of NEWS-A and IPAQ-L questionnaires were completed in the survey. Finally, the BMI, BFP, and BP were measured. The questionnaires were filled by our research team members through one-to-one interview to ensure the quality.

Measures

The NEWS-A questionnaire was used to evaluate BE near the living places of the participants. Standard measures were generated to describe eight dimensions, including residential density, the diversity of land use, facility access, street connectivity, walking and cycling facilities, the aesthetics of the environment, pedestrian safety, and crime safety[21].

IPAQ-L was used to assess PA levels during the past 7 days, including work-related PA, transport PA, domestic and gardening PA, and leisure PA. IPAQ-L is a measure of PA by metabolic equivalent (MET). For further analysis, the total METs of the participants were divided into different groups. The MET values of the participants were ranked in ascending order and then divided equally into three groups. The lowest third of

them were in the Low-PA group, the middle part was in the Moderate-PA group, and the rest were in the High-PA group.

Body composition test was performed by Inbody 230 (IT: Biospace Co Ltd, Seoul, South Korea). The participants removed all metal objects from the body, and took off the shoes and socks during the test. The metal area of the machine was in direct contact with the skin.

Trained staff measured BP using an Omron 1000 (IT:Omron Healthcare Europe BV, Hoofddorp, The Netherlands) automated device with the appropriate cuff size for measured mid-upper-arm circumference after the participants was seated at rest for at least 2 min. Blood pressure measurements were taken on the left arm of each participant in a sitting position. Two readings were made 3–4 min apart and the averaged reading were recorded.

Statistical Analysis.

Independent variables included eight dimensions of environment variable (residential density, the diversity of land use, facility access, street connectivity, walking and cycling facilities, the aesthetics of the environment, pedestrian safety, and crime safety). PA, BMI, BFP, and BP were dependent variables. The correlation between BE, PA and health measures was analyzed by SPSS 24.0 software (SPSS Inc., Chicago, IL). Descriptive statistics were used to describe sample characteristics. General linear regression was used to analyze the association of BE with PA and health measures of women living in Lianhu District. Age was the control variable. Statistical significance was set at $P<0.05$.

Results

In total, 207 participants took the survey. Five participants were excluded because of missing questionnaire data, and 202 participants were in the final sample. Table 1 presents the characteristics of the participants. Seventy-eight women aged 16–40 yrs (38.6%), eighty-two women aged 41–60 yrs (40.6%), and forty-two over 60 yrs (20.8%) were included. Most of the respondents had jobs (76.2%), and had 3–4 family members (62.9%).

The MET values of Low-PA, Moderate-PA and High-PA in the different types of PA level groups were shown in Table 2. For all the participants and those in High-PA group, working PA accounted for the largest proportion, while traffic PA accounted for the smallest proportion. In the Low-PA and Moderate-PA groups, the proportion of household PA was the largest, and that of working PA was the smallest.

The correlations were shown in Table 3. Residential density was negatively associated with transportation PA ($P<0.05$). No significant correlation was found between BE and leisure time PA. The correlations between BE and BMI, BFP, SBP, DBP were analyzed (Table 4). In the High-PA group, traffic safety was positively correlated with BFP ($P<0.05$). In the Moderate-PA group, traffic safety was positively correlated with SP, and land use mix access was negatively associated with DBP ($P<0.05$). In the total PA group, traffic safety was negatively correlated with BP ($P<0.05$). No significance was found in other aspects ($P>0.05$).

Discussion

The present study applied questionnaire survey and health test to identify characteristics and relationships of BE with PA, BMI, BFP, BP among 202 adult women in Lianhu District of Xi'an City. We found that participants with different PA levels engaged in diverse types of PA. Women in the High-PA group were mainly engaged in working PA, while those in the Moderate-PA and Low-PA groups were mainly engaged in household PA. In Lianhu District, higher residential density was negatively associated with transportation PA and BMI, while traffic safety was positively correlated with BFP. For different groups of PA levels, traffic safety was positively correlated with SBP, while land use mix access was significantly negatively correlated with DBP in the Moderate-PA group. In the High-PA group, traffic safety was positively correlated with BFP.

In our study, significant negative correlation existed between residential density and traffic PA among women living in the Lianhu District. That is, the more high-rise buildings near the residential area and the denser the population density, the lower level of traffic PA. This is consistent with several previous studies. It is possible that high levels of residential density may not be conducive to other forms of active transport, such as cycling [22]. One study has found that Flemish older adults living in urban areas were less likely to cycle everyday than those living in semi-urban (i.e., less dense) areas [23]. The high residential density and good land use mix–diversity were also reported both associated with less leisure walking among women [24]. In our study, the tourism industry in Lianhu District is well developed and there are many floating populations. The travel of residents is more relied on subway transportation, which reduces the amount of PA related to transportation. High residential density may have higher land mix utilization rates than those with low residential density, which may result in excessive car and pedestrian traffic, thereby interfering with traffic-related walking. The results of research in each region may be different [25–27], due to differences in sample characteristics (e.g., children and adolescents, older adults, women), use of different spatial analytic techniques, the geographic scope of the study area（e.g., district，county, city, province）, and the scale differences for the analyses (i.e., individual's and census tract). Further research is in need to explore the exact relationship between residential density and PA in larger sample.

We also found a negative association between residential density and BMI [28]. Higher density of walking destinations, population density and lower percent residential were associated with decreases in BMI. BE can influence PA of residents, and the higher the level of PA, the lower the probability of obesity [29]. Meanwhile, other studies have found no correlation between residential density and the incidence of obesity (BMI) [30,31].

In our analysis, the traffic condition near the residence has a significant positive correlation with BFP of the all participants in the survey and the female in the group with high level of PA. We did not find any similar studies to support the result. BFP is the percentage of fat content in total body weight, which can reflect the degree of obesity in the body. Some studies have found that higher level of PA was related to lower probability of obesity and smaller BFP[32,33].The team members in our study conducted field surveys of residential areas studied, and there was almost no traffic jam and the no driver exceed the speed limit. However, we found that the number of fast food restaurants, specialty restaurants and snack bars in the survey area was more than other residential areas. The number of restaurants and convenience stores near residential has been shown to have an impact on obesity [34–36]. In addition, considering the local food

culture, the local eating habits in the city of Xi'an are oily and spicy, with noodle as the main food. Therefore, the reasons for the research results were not only related to the construction environment, but also the eating habits and so on, which were also one of the significant factors affecting the obesity of residents.

Our findings regarding the relationship between BE and BP may also have important implications for understanding the relationship between BE and women's health. There was a significant negative correlation between residential density and BP. Higher levels of residential density was associated with healthier BP. Meanwhile, in the Moderate-PA group, land use mix access was negatively correlated with DBP. The closer public places, bus stations, subway stations, etc., the more convenient the travel was, and the lower DBP value was. Previous studies have also confirmed the relationship between BE and BP: With closer public places, bus stations, subway stations, etc. to home, residents may prefer to walking or riding bicycles, accumulate more PA, and thus the risk of hypertension may be lower[37,38].However, traffic safety was positively correlated with SBP in the Moderate-PA group. It is possible that their PA levels were high and the association of BE and BP was relatively weak. The relationship between BE and BP need to be further investigated in larger population.

The strengths of our study included: firstly, the selected research area was representative, and it was also the first time in China to analyze the correlation of the architectural environment of a historic city with residents' PA and health. Secondly, the NEWS-A□IPAQ-L are internationally recognized and have high reliability and validity, which can effectively provide the data needed for this study. Finally, the quality of questionnaire filling was high, which avoided the deviation of data caused by different understanding of personal subjective factors. The present study had several limitations. Firstly, the scales used were subjective, although we avoided deviations as much as possible in the process. Secondly, the sample size was small, and the survey area was limited to Xi 'an. Finally, social and psychological factors were not studied in this study. Some research has shown that social support and self-efficacy may also be correlated with residents' PA and health status.

Conclusions

This study confirms the relationship of BE with PA, BMI, BFP, and BP in Chinese women living in the city of Xi'an. Higher residential density was negatively associated with transportation PA and BMI, while traffic safety is positively correlated with BFP. The associations between BE and health were mixed in different PA groups. Further research is necessary to dig out the exact impact of BE on PA and health in this population.

Abbreviations

BE: built environment

BMI: body mass index

BFP: body fat percentage

BP: blood pressure

DBP: diastolic blood pressure

MVPA: moderate-to-vigorous physical activit

PA: physical activity

SBP: systolic blood pressure

Declarations

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Availability of data and materials

Any investigator is welcome to access the data through ysun@snnu.edu.cn.

Authors' contributions

YS, WZ, CH conceptualized and designed the study. JH, ZC, FS, XZ analyzed and interpreted the data. All authors contributed in data interpretation and writing the manuscript. All authors read and approved the final manuscript.

Role of the funder/sponsor

The funders had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; or the decision to submit the manuscript for publication.

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Ethics approval and consent to participate

All participants gave informed consent, and the study was approved by the institutional review boards of all participating institution. No participants were under 16 years old.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1. Demographics of the participants (N=202)

	n	%
Age		
16~40 years	78	38.6
41~60 years	82	40.6
≧60 years	42	20.8
Work status		
Employed	154	76.2
Unemployed	48	23.8
Number of family members		
1-2	35	17.3
3-4	127	62.9
≧5	40	19.8
Marital status		
married	169	83.7
unmarried	33	16.3

Table 2. PA of participants in different PA groups

	Low -PA (Mean±SD)	Moderate-PA (Mean±SD)	High-PA (Mean±SD)	Total (Mean±SD)
MVPA (MET*min/week)	1520.8±841.9	5075.2±1471	14151.4±6998.6	6915.8±6744.3
Traffic PA (MET*min/week)	453.9±442.7	1070.1±694.6	2049±2180.2	1194±1483.4
Leisure time PA (MET*min/week)	247.9±302.2	1343.8±1145.3	2101±2937.3	1230.9±1960.4
Working PA (MET*min/week)	218.5±478.1	822.1±1075.2	6105.7±8624.7	*2382.1±1960.4*
household PA (MET*min/week)	600.6±592	1839.2±1267.3	3895.6±3573.6	2111.8±2579.2

Note: PA indicates physical activity, MVPA indicates moderate-to-vigorous physical activity.

Table 3. Correlation between BE and transportation PA, leisure time PA

	Transportation PA			Leisure time PA		
	B	SE	*P*	B	SE	*P*
Residential density	**-2.584**	**1.125**	**0.024***	0.096	1.273	0.94
Land use mix access	-0.406	1.558	0.795	0.818	323.694	0.998
Street connectivity	-289.208	289.574	0.321	475.927	431.045	0.273
Walking/cycling facilities	94.009	216.905	0.666	-40.522	297.736	0.892
Aesthetics	-63.577	314.982	0.841	-97.894	399.384	0.807
Traffic safety	-22.104	234.801	0.925	44.623	367.329	0.23
Crime safety	-220.618	308.426	0.477	-109.574	495.911	0.826
Land use mix diversity	229.615	229.774	0.321	270.644	241.311	0.265

Note: BE indicates built environment, PA indicates physical activity, MVPA indicates moderate-to-vigorous physical activity, * indicates significant correlation (P<0.05).

Table 4. Correlation between BE and BMI, BFP, SP, DP in different PA groups

Note: BE indicates built environment, BMI indicates body mass index, BFP indicates body fat percentage, SBP indicates systolic blood pressure, DBP indicates diastolic blood pressure, PA indicates physical activity, MVPA indicates moderate-to-vigorous physical activity, * indicates significant correlation (P<0.05).

		BMI			BFP			SBP			DBP		
		B	SE	P	B	SE	P	B	SE	P	B	SE	P
Low-PA	Residential density	-0.003	0.006	0.64	0.01	0.012	0.42	-0.035	0.026	0.191	-0.009	0.018	0.629
	Land use mix access	-1.77	1.355	0.21	-0.839	2.967	0.78	2.257	7.260	0.759	3.471	4.768	0.474
	Street connectivity	-0.838	0.992	0.41	-0.05	2.124	0.98	-3.064	4.301	0.484	-1.621	2.865	0.577
	Walking/cycling facilities	0.996	1.066	0.36	1.722	2.258	0.46	1.022	5.737	0.860	4.082	3.707	0.283
	Aesthetics	0.11	1.190	0.93	1.662	2.473	0.51	0.318	6.328	0.960	0.214	4.197	0.960
	Traffic safety	1.968	1.487	0.2	4.153	3.126	0.2	8.110	7.837	0.312	8.335	5.017	0.111
	Crime safety	-1.631	1.077	0.09	-3.356	2.325	0.165	0.9	5.379	0.869	-4.699	3.426	0.184
	Land use mix diversity	0.641	0.922	0.50	2.623	1.869	0.18	0.584	4.719	0.903	2.771	3.074	0.377
Moderate-PA	Residential density	-0.001	0.004	0.80	0.001	0.008	0.9	-0.031	0.030	0.323	-0.021	0.021	0.327
	Land use mix access	1.759	1.245	0.174	0.745	2.465	0.77	-16.13	3.209	0.095	**-13.8**	**6.031**	**0.033***
	Street connectivity	0.095	0.638	0.88	-0.723	1.194	0.55	0.394	4.856	0.936	-0.936	3.321	0.781
	Walking/cycling facilities	0.358	1.014	0.73	0.070	1.920	0.97	-2.935	7.736	0.708	-0.723	5.316	0.893
	Aesthetics	0.330	0.312	0.58	1.368	1.121	0.24	-7.179	4.435	0.121	-4.046	3.102	0.207
	Traffic safety	-0.476	1.214	0.72	-2.262	2.469	0.37	**20.89**	**9.710**	**0.044***	11.91	6.883	0.099
	Crime safety	-0.049	0.550	0.93	-0.432	1.048	0.685	0.433	4.521	0.925	-0.679	3.094	0.828
	Land use mix diversity	0.204	0.704	0.78	0.359	1.329	0.79	-5.874	5.175	0.270	-6.437	3.363	0.070
High-PA	Residential density	-0.006	0.003	0.07	-0.010	0.006	0.090	-0.025	0.020	0.227	-0.025	0.015	0.101
	Land use mix access	-0.478	0.954	0.62	-0.814	1.678	0.63	-2.099	6.094	0.733	2.846	4.456	0.528
	Street connectivity	0.212	-0.77	0.79	0.127	1.394	0.93	1.217	4.773	0.801	3.894	3.432	0.266
	Walking/cycling facilities	0.414	0.913	0.66	1.809	1.568	0.26	9.611	5.489	0.091	3.106	4.216	0.468
	Aesthetics	0.760	0.875	0.40	1.232	1.543	0.43	3.337	5.166	0.524	2.055	3.806	0.594
	Traffic safety	1.140	1.173	0.34	**4.120**	**1.92**	**0.043***	-11.53	6.742	0.099	-0.046	5.218	0.993
	Crime safety	0.439	0.788	0.58	-0.917	1.381	0.51	-6.140	4.735	0.206	0.435	3.586	0.904
	Land use mix diversity	0.099	0.855	0.908	0.304	1.502	0.84	2.001	5.270	0.707	-0.343	3.884	0.93
Total	Residential density	**-0.005**	**0.002**	**0.04***	0.004	0.005	0.372	**-0.030**	**0.014**	**0.033***	**-0.021**	**0.009**	**0.03***
	Land use mix access	-0.396	0.639	0.537	-0.321	1.266	0.801	-3.49	4.0	0.039	0.489	2.760	0.860
	Street connectivity	-0.128	0.443	0.773	-0.313	0.876	0.722	-0.218	2.68	0.935	0.688	1.840	0.709
	Walking/cycling facilities	0.46	0.562	0.416	1.113	1.11	0.32	4.074	3.549	0.255	2.288	2.446	0.353
	Aesthetics	0.204	0.467	0.664	0.774	0.92	0.404	-0.362	2.989	0.904	-0.251	2.054	0.903
	Traffic safety	1.221	0.107	0.098	**3.245**	**1.412**	**0.024***	-0.606	4.558	0.895	4.927	3.080	0.114
	Crime safety	-0.205	0.072	0.644	-1.065	0.863	0.221	-1.811	2.728	0.509	-0.765	1.877	0.685
	Land use mix diversity	0.354	0.468	0.452	1.159	0.918	0.211	-0.196	2.938	0.947	-0.684	2.017	0.735