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The Impact of Built Environment on Walkability, Case Study: North-West of Shiraz*

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ABSTRACT: Physical activity is connected with adults' health in many ways, and walking is the most popular form of physical activity among adults all over the world. The authors have previously studied this issue in an under-construction environment in a new town in a developing country. The present study investigates the impact of built environmental features and qualities on walkability in developed areas in relatively well-to do neighborhoods in a city (Shiraz). The 34 effective variables of the built environment on walkability are extracted from the literature. Built environmental features and residents' transport and recreation walking were gathered through perceived manner. Factor analysis was, then, run for the measured built environment features, from which 8 factors were extracted. They were interpreted in terms of related variables. This study reveals that the only qualities that have significant effect on recreation walkability are comfort and attraction, safety, aesthetics whereas transport walking is only influenced by steepness of sidewalks. Contrary to the existing literature, Accessibility, public transportation, pollution, and sidewalk quality have no significant effect on walkability. These results demonstrate that lifestyle factors such as personal free time, pedestrian-related habits, car-dependence habits, sexualized habitus, inabilities, etc. are very crucial in determining the effective built environment features and qualities on walking behaviors.

Keywords: Walkability, Transport and Recreation Travel, Built Environment Features, Urban Design Qualities, Shiraz.

INTRODUCTION

Physical Activity, Walkability and Built Environment Features

Physical activity and walkability may be discussed from different points of view. One of the most important one is that walking is the most popular form of physical activity among adults (Bentley et al., 2010; Sportscotland, 2008; Armstrong et al., 2000). On the one hand, Physical activity is associated with a number of positive health outcomes, such as increased longevity (Sundquist et al., 2004). On the other hand physical inactivity is strongly associated with numerous chronic conditions including obesity, diabetes mellitus type 2 (Manson et al., 1992), hypertension, cardiovascular disease (Sesso et al., 2000; Sundquist et al., 2005), breast cancer, depression, and osteoporosis, which in turn affect premature mortality (WHO, 2011; US Department of Health and Human Services, 2002; Kopelman, 2000).

In order to decrease these global widespread diseases, the importance of more physical activity has been strongly emphasized by World Health Organization (WHO, 2010). Since physical Inactivity is associated with major chronic diseases; interventions to promote healthy and active life styles are needed.

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Although, physical activity is also affected by personal and social factors (Giles-Corti et al., 2005), recently attention has been drawn to the relationship between physical activity and built environment attributes (Sundquist et al., 2011). This has led researchers and policy-makers to put stronger emphasis on the impact of built environment features on walking (Bentley et al., 2010, National Heart Foundation, 2009; WHO, 2007). There is also a growing body of researches that find the relation between built-environment design and active living (Almanza et al., 2012 and McCormack et al., 2004).

Due to the catastrophic increase in obesity and its consequences in contemporary cities, numerous studies have been conducted in different parts of the world to deal with this problem. These studies have demonstrated that obesity has become a prevalent serious health concern in urban areas (Shill et al., 2012; Sugiyama et al., 2012). With the exception of a few African and Latin American studies, most previous studies have been conducted in the USA, Australia and Europe (Van Dyck, 2013).

It is claimed that the prevalence of obesity, overweight, and hypertension in Iran is as high as in the US (Bahrami et al., 2006). Furthermore, Iranian women are more obese than American women (Bahrami et al., 2006). Despite the strong association between the built environment and physical activity, few studies have examined this relationship in Iran[1].

METHODOLOGY

Walkability-Related Built Environment Features and Urban Design Qualities

Based on the presented conceptual framework, the built environment features should be extracted through which walk-ability related urban design qualities become possible. In literature, various built environment attributes have been mentioned as promotion for residents' walking behaviors. For example: traffic density and safety; public transportation; access to green space, shopping centers and recreation (Table 1).

In order to develop a practical framework in which a large data set of features being reduced to a limited number of qualities for the sake of easy handling (Everitt and Dun, 1991), and also to eliminate multi-colinearity between variables, the built-environment features should be categorized in terms of a few qualities (factors). Various studies have proposed frameworks to link built-environment qualities with people's walking patterns. One suggested framework includes four main dimensions: safety (physical environment, lighting, traffic safety, etc.), aesthetics (trees, parks, architectural design and pollution), functional quality (characteristics of the street and path), and qualities of destinations (availability of commercial and community facilities) (Pikora et al., 2006; Pikora et al., 2003, Kamphuis et al., 2008). Some other qualities, such as continuity, complexity and human scale, have also been used as frameworks[2].

First, it is intended to extract the effective built environment features (indicators) on walkability from the literature. Booysen (2002) has asserted that indicators could be classified and evaluated according to a number of general dimensions. He further claimed that the selection of indicators should be "generally based on theory, empirical analysis, pragmatism or intuitive appeal, or some combination thereof." Some other researchers (e.g. Zebardast, 2008) believe that the central consideration in selection of indicators should be based on the purpose of the measurement.

To select the appropriate indicators to reflect the urban design domain of walkability, related literature, including theories and empirical studies were reviewed. Local conditions and characteristics were also taken into consideration. On this basis, 35 indicators were selected (Table 1). "Fear due to the abandoned buildings" was extracted from the local conditions and added to the indicator list.

Table 1. Selected Indicators to Measure Urban Design Domain of Physical Activity

1	Access to Sport Facilities	Manaugh & El-Geneidy (2011), Harrington & Elliott (2009)
2	Access to Leisure and Entertainment Centers	Sundquist et al., (2011), Hoehner et al., (2012)
3	Access to Retails (Small Shops and Stores)	Ewing & Cervero (2010), Leyden et al., (2011)
4	Access to Shopping Centers	Vine et al., (2012), Van Dyck et al., (2009)
5	Access to Gardens and Parks	Lachowycz & Jones (2011), Mytton et al., (2012), Coombes et al., (2010), Gomez et al., (2010), Sugiyama et al., (2010), Shill et al., (2012)
6	Fear of Crimes	Bentley et al., (2010), Hosseini et al., (2012), Anderson et al., (2011)
7	Fear of Injury Due to Slipping	Giles-Corti et al., (2013), Hoehner et al., (2012)
8	Fear of Accident	Gallimore et al., (2011), VanDyck et al., (2013)
9	Fear of Stray Dog	Hoehner et al., (2012)
10	Fear of Darkness	Bias et al., (2010), Cao et al., (2009)
11	Fear of Loneliness	Cerin et al., (2012)
12	Fear of Lack of Social Monitoring	Caspi et al., (2012)
13	Fear of Undeveloped Plots	Talen & Koschinsky (2010)
14	Having Personal Vehicle	Turrell et al., (2013)
15	Public Transportation Quality	King et al., (2011), Wey & Chiu (2013), Rosenberg et al., (2009), Dunton et al., (2012)
16	Distance to Public Transportation	Brown et al., (2009), Gebel et al., (2011)
17	Sidewalk Width	Wolch et al., (2010), Gunder (2011), Marzoughi & Vanderburg (2010)
18	Car-Pedestrian Separation	Parra et al., (2010), Lee et al., (2012)
19	Sidewalk Steepness	Andrews et al., (2012), Koh & Wong (2013)
20	Different Levels of Sidewalk	Koh & Wong (2013), Caspi et al., (2012)
21	Stalls in Sidewalk	Koh & Wong (2013), Wood et al., (2010)
22	Sidewalk Discontinuity (Due to Street Crossing)	Oluyomi et al., (2012), Nolon & Salkin (2011)
23	Sidewalk Discontinuity (Due to Obstacles)	Bias et al., (2010), Cerin et al., (2012)
24	Mixed Use	Ball et al., (2012)
25	Others Presence/ Seeing Neighbors During Walking	Cao et al., (2009), Almanza et al., (2012)
26	Building's Aesthetics	Guo & Loo (2013), Griffin et al., (2012)
27	Building and Population Density	McCormack et al., (2004)
28	Greenness	Lwin & Murayama (2011), Wheeler et al., (2010), Berrigan et al., (2010)
29	Ornamentation	Guo & Loo (2013)
30	Resting Facilities	Stangl (2011)
31	Furniture (Fountains and Trash Cans)	Lee (2012)
32	Maintenance	Kelly et al., (2011), Stangl (2011)
33	Air Pollution	Van Dyck et al., (2011), Hodgson et al., (2012)
34	Noise	Parra et al., (2010), Hunter et al., (2011), Hand et al., (2011)

CASE AND SAMPLE SELECTION

The study area was Shiraz north-west zone (Fig. 1), with a population of 30584 in 2011. The randomly selected samples of the area were composed of 863 adults, aged 18–96 (Mean 38.82, 43.8% women and 56.2% men).

The study population is relatively homogenous in education and income level (Table 2). Based on the July 12, 2011 census data of The Iran Statistical Center, residents in the study area, in comparison to the other zones of the Shiraz, are mostly white-colored, of high income and highly educated (Census of Population and Housing, 2011).

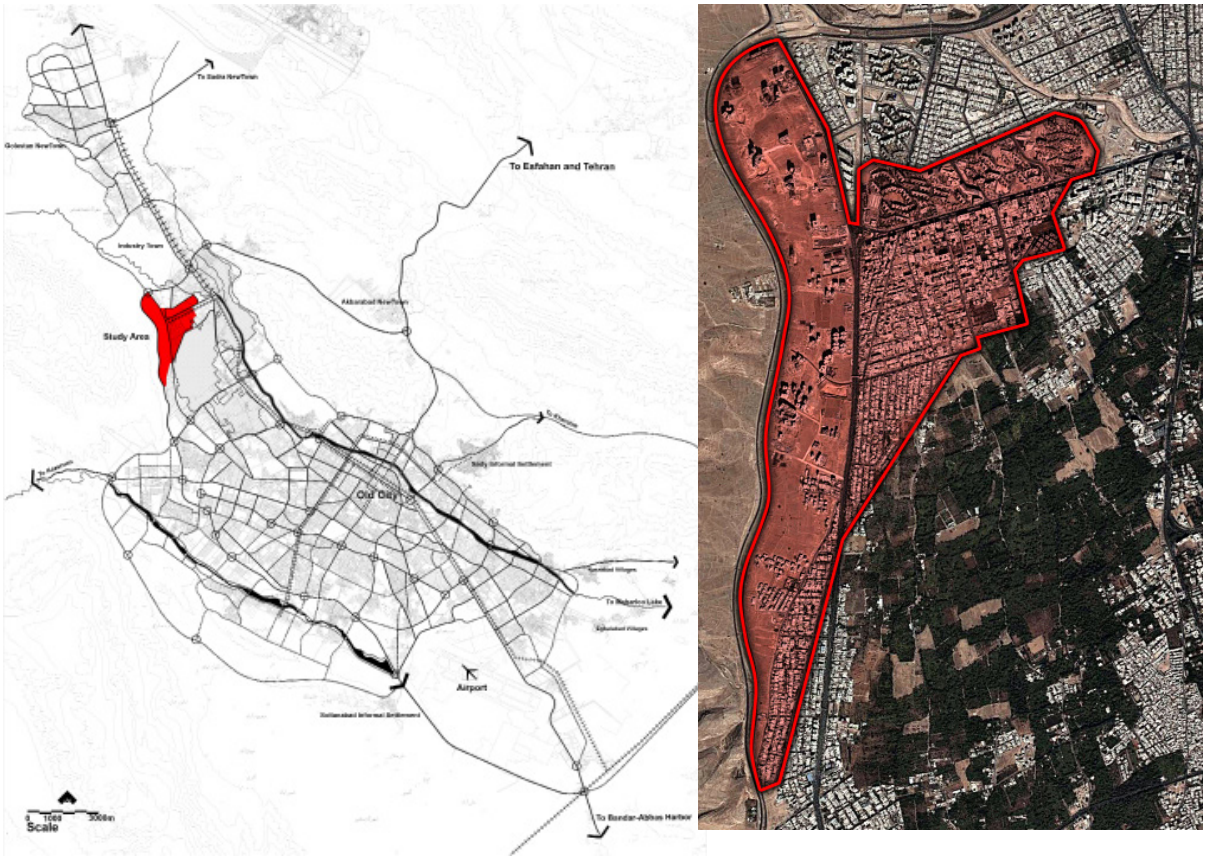

Fig. 1. Shiraz Metropolitan Area (The Study Area is Shown in Black)

Table 2. Descriptive Statistics of Socio-Economic Categories

	Percent
Job Categories	
Self-Employed	16.0
Government	29.6
Student	15.0
Unemployed	37.1
Income Level	
Less than 333$	47.4
Between 333 and 666$	39.0
More than 666$	3.8
Education	
Illiterate	2.3
Under Diploma	10.8
Diploma (4-Year High School)	24.4
2-Year College	13.1
Bachelor	41.8
Master	3.3
Ph.D	1.4

In spite of the homogenous population of the study area, the different parts of the study area vary in some aspects, e.g. access to retail stores, shopping centers, sport and entertainment facilities, greenness; and ornamentation, and sidewalk attributes (widths, continuity/discontinuity, and change in levels) differ within the area (Fig. 2).

Fig. 2. The Degree of Greenness, Enclosure, Sidewalk Widths, Vacant Plots and Access to Retail

DATA COLLECTION

A great body of research illustrates that objective and perceived built environment factors are positively affecting physical activity in adults (Brownson et al., 2009). This study, like the growing body of research supporting the links between built environment features and walkability (Cerin et al. , 2012), is based on self-report data. The questionnaires were administered through face-to-face (in-home) interviews by interviewers with experience of conducting population surveys. The following two main data categories were collected:

- Residents' walking amount
- Built-environment variables

The former was assessed through a cross-sectional survey, using the Global Physical Activity Questionnaire (GPAQ), to measure the time that residents normally spend on different types of walking. In this study, like some other recent studies (Bentley et al., 2010; Powell et al., 2003; Pikora et al., 2006), walking was divided into two different domains: transport, and recreation travel. This was done due to significant differences between these two types of travel. Transport travel is defined as activity primarily used to reach a specific destination, such as: employment and education centers, local stores and sport facilities. While, recreation travel is an activity in which no specific, fixed destination is intended. The purpose of this type of activity is, therefore, primarily leisure, examples are: strolling, walking, brisk walking, running and bicycling (Bahrainy and Khosravi, 2013).

For the latter, three methods were used to collect the data for measuring the features of the built environment in relation to walkability, (Brownson et al., 2009): a- perceived measurement (Handy et al., 2002; Sallis et al., 1997), b- auditing (Lee et al., 2005; Troped et al., 2006), and c) objective analysis, using GIS (Ewing et al., 2003). Due to the importance of the residents' perception of the built environment in walkability, as human behavior, the first method—perceived measurement—was used in the present study.

RESULTS AND DISCUSSIONS

Deriving Effective Urban Design Qualities

Factor analysis was run for 35 selected indicators, using SPSS software. To test the overall sampling adequacy, Bartlett's Sphere Test and KMO were used (Sharma, 1996, p. 116) (Table 3). When the factor analysis was done, using Varimax rotation, it yielded a clear factor structure with eight factors that explained 66.44% of the total variance (Table 4). According to the correlated high loadings, dimensions represented by factors respectively called F 1: ''sidewalk quality'' F 2: ''safety'' F 3: ''accessibility'' F 4: ''comfort and attraction'' F 5: "public transportation" F 6: "pollution" F 7: "architectural aesthetics" F8: "sidewalk steepness."

Table 3. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.749
Bartlett's Test of Sphericity	Approx. Chi-Square	1.809E3
	df	351
	Sig.	0.000

Table 4. Total Variance Explained and Factor Loading Matrix for the Urban Design Sub-Domain of Walkablility (Rotation Method: Promax with Kaiser Normalization)

	Indicators	F1	F2	F3	F4	F5	F6	F7	F8	Communalities
1	Sidewalk Discontinuity Due to Obstacles	0.82								0.625
2	Sidewalk Discontinuity Due to Streets	0.76								0.602
3	Sidewalk Width	0.70								0.585
4	Car-Pedestrian Separation	0.68								0.631
5	Fear of Injury Due to Slipping/ Skidding/Stumbling	0.59								0.576
6	Uneven Sidewalk	0.48								0.551
7	Stands in Sidewalk	0.41								0.596
8	Fear of Loneliness Access to Leisure and Entertainment Centers		0.91							0.763
9	Fear of Darkness		0.79							0.731
10	Fear of Crime		0.62							0.593
11	Fear of Strayed Dogs		0.58							0.575
12	Fear of Lack of Social Monitoring		0.44							0.479
13	Access to Leisure and Entertainment Centers			0.78						0.769
14	Access to Small Shops and Stores			0.78						0.657
15	Access to Shopping Centers			0.71						0.688
16	Access to Sport Facilities			0.65						0.684
17	Access to Gardens and Parks			0.64						0.679
18	Greenness				0.93					0.778
19	Ornamentation				0.83					0.709
20	Resting Facilities				0.68					0.669
21	Quality of Public Transportation					0.79				0.674
22	Distance to Public Transportation					0.74				0.655
23	Air Pollution						0.85			0.803
24	Noise						0.63			0.735
25	Building's Aesthetics							0.82		0.750
26	Existence of Undeveloped Plots							0.50		0.700
27	Sidewalk Steep								0.70	0.680
	Eigenvalues	5.17	3.76	2.37	1.80	1.53	1.24	1.06	1.01	
	% Explained Variance	19.14	13.93	8.78	6.68	5.66	4.61	3.91	3.74	
	% Total Explained Variance				66.439					

INVESTIGATING THE IMPACT OF URBAN DESIGN QUALITIES ON WALKABILITY

After adjusting socioeconomic factors, linear regressions between factors and residents' walking show stronger correlation between derived factors and recreation walking (R Square= 0.208) in comparison to transport walking (R Square= 0.184). These also show that the only effective factor on transport walking (travel) is the "sidewalk steepness" (Table 5 and 6), whereas recreation walking (travel) is influenced only by "comfort and attraction", "architectural aesthetics" and "safety" (Table 7 and 8)

Table 5. Model Summary Between Transport Walking and Built Environment Qualities (Method = Stepwise)

Model	R Square	Std. Error of the Estimate	F	Sig.
1	0.184	405.114	7.338	.007

Table 6. Coefficients of Transport Walking and Built Environment Qualities

Model		Standardized Coefficients	T	Sig.
		Beta		
1	(Constant)		8.912	.000
	Sidewalks' Steep	0.304	2.709	.007

Table 7. Model Summary between Recreation Walking and Built Environment Qualities (Method = Stepwise)

Model	R Square	Std. Error of the Estimate	F	Sig.
1	0.208	368.426	8.472	.005

Table 8. Coefficients of Recreation Walking and Built Environment Qualitie

Model		Standardized Coefficients	T	Sig.
		Beta		
1	(Constant)		0.544	.000
	Safety	0.169	2.254	.049
	Comfort and Attraction	0.230	3.108	.004
	Architectural Aesthetic	0.192	2.547	.023

CONCLUSION

Because physical activity is strongly associated with numerous chronic conditions, and walking is the most popular form of physical activity among adults, health-related policies and research have recently put strong emphases on how the built environment influences walking.

In this paper the walkability-related built environment features were extracted from the literature, the residents' walking data collected through interview, on the basis of perceived measurement. Because of the mediatory role of perceptions between the built environment features and walking behaviors and also the fact that physical features individually could not adequately explain the experience of walking and also for the sake of easy handling and interpretation of the results, the large data set of built environment features were reduced to eight urban design qualities.

In contrast to other studies, the present study shows that there is no significant relationship between walkability and the qualities of accessibility, sidewalk quality, public transportation, and even pollution. Contrary to the results of studies which are mostly conducted in USA, Canada and European countries, the findings of this research show that residents' walking behaviors in the study area as a metropolitan area of a developing country, is not significantly affected by accessibility to leisure, entertainment, shopping and sport centers. It is also not determined by quality of sidewalks, or even the quality of public transportation.

These results lead us to conclude that lifestyle factors such as personal free time, pedestrian-related habits, car-dependence habits, sexualized habitus, inabilities, etc. are very crucial in determining the effective built environment features on walking behaviors. In the other words, the hypothesis appear in the mind is that in each culture certain urban design qualities are more important. The future international research, including developed and developing countries, could clarify the effective role of life style versus built environment on the physical activities in urban spaces.

The relationships found by this study suggest that particular neighborhood characteristics may identify useful intervention strategies to increase specific kind of residents' walking. According to the results, the only quality significantly related to transit walkability is "sidewalk steepness" and the qualities affect the recreation walkability include "comfort and attraction", "architectural aesthetics" and "safety". The study shows that recreation walking is strongly dependent on urban design qualities.

With regard to "comfort and attraction", the greenness of urban spaces is the most effective attribute of walking behaviors. After that, ornamentation like lighting, illuminating, flowering, statues, fountains, and garbage cans could also increase residents' walking time. Resting facilities, like chairs and benches, also have their shares. It seems that, the higher the residents' age, the higher the importance of this resting facilities. Future studies in this context, focusing on the elderly needs, could develop some useful ideas on the issue.

As for the "architectural aesthetics", this study shows that building appearance and developed/undeveloped parcels alongside the sidewalks have significant impact on residents' walkability. Further study is needed to investigate the role of visual information, buildings' typologies, the overall harmony and paths' enclosure on walkability.

"Safety" also has a slight effect on recreation walking. Appropriate strategy to enhance this quality is to make the residents presence in urban spaces more frequent. Locating buildings at the plot edges with adequate illumination could promote the social monitoring, which will, in turn, lead to crime prevention.

With regard to the "sidewalk steepness", using topography as the basis of proposed urban morphology, in a way in which the paths follow the topography's lines, and preventing harsh crossing, could lead to acceptable sidewalks steep. This is especially important in the case of transport travels -that is the path leading to the job or education centers, public transportation stations, shopping centers, etc.

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ENDNOTE

1-Bahrainy and Khosravi, 2013.
2-Bahrainy and Khosravi, 2013.

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