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Analyzing the Impact of the Physical Form of Neighborhoods on Walkability: a Case Study of Haft Hoz and Baghe-e-Feyz Neighborhoods in Tehran

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Abstract

The present study aimed to evaluate the impact of the physical form in neighborhoods on walkability to explains the effect of the urban element on physical activity. Haft Hoz (with grid pattern) and Bagh-e-Feyz (with organic pattern) were selected due to the different spatial configurations. The social and economic conditions were identical to avoid the impact of intervening variables. The spatial configuration and order were investigated by using the space syntax technique and Depth Map Software. The typology and field survey methods were used to evaluate the characteristics of the blocks and parcels and land use, respectively. In addition to examining the physical forms in the neighborhoods objectively, the subjective technique was used by interviewing the residents and achieving theoretical saturation. Based on the results, spatial configuration, blocking pattern and parcel, and land use affect walkability.

Keywords: Physical Elements of Form; Spatial Configuration; Grid Fabric; Organic Fabric; Walkability

1. Introduction

Recent studies indicate that physical and mental health have a meaningful relation to environment characteristics (Frank et al., 2005; Frank et al., 2009; Saelens et al., 2003). Physical health influences a wide area such as urban design, physical activities, walking behavior) and generally needs accurate laboratory methods and tools to assess. A large number of studies considered walking behavior as one of the aspects of physical health (Lee & Moudon, 2006; Cutumisu, 2011; Buck, 2015). In the specific context, studies were conducted on the relationship between the quality of urban form and people's tendency to physical activity and walking. However, some studies showed that practicing physical activities in the urban environment is affected by individual characteristics (age, gender, and psychological characteristics) in addition to the physical environment where people live and work. Moreover, the environmental and physical aspects of the built environment are considered as the effective components that can facilitate or limit physical activity (Mitchell, 2016 Adopted by Feng et al., 2010; Forsyth et al., 2009; Giles-Corti et al., 2009; Handy et al., 2002; Papas et al., 2007). By providing a brief discussion, the relationship between the physical environment and activity in general and walkability in specific were highlighted. The main research questions are as follows:

Question One: Does the physical form of neighborhoods affect walkability?

Question Two: How do the elements of the physical form of neighborhoods affect the behavior?

Question Three: What are the principles and guidelines for designing local streets that enhance walkability?

The structure of the present study is as follows. In the first section, the urban form and its elements are defined from the perspective of theorists. In section 2, based on the studies conducted on influencing the form of the physical activity from one side and the walkability from the other side, the effective elements, and indices of physical forms of neighborhoods on walkability are introduced. Then, methods of analyzing the urban form are examined, and the research questions are evaluated in the selected neighborhoods. Finally, the conceptual framework (applied model of research) is developed, and the case study is analyzed based on the framework.

2. Research Background

The following two research areas were studied to investigate the research background:

A) The field of built environment's influence on (physical) health: the significant relationship between physical and mental health and the features of the built environment was reviewed in various studies (Frank, Sallis, Saelens, Leary, Cain, Conway, & Hess, 2009; Frank, Schmid, Sallis, Chapman, & Saelens, 2005; Saelens, Sallis, Black, & Chen, 2003; Rebecchi, Buffoli, Dettori, Appolloni, Azara, Castiglia, D'Alessandro & Capolongo, 2019; Fathi, Sajadzadeh, Mohammadi Sheshkal, Aram, Pinter, Felde & Mosavi, 2020). Some domestic studies have also addressed the influence of the built environment on physical health at the scale of the neighborhood and with emphasis on defining urban design guidelines (Qasemzadeh, 2016). Besides, large-

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scale studies have examined the relation of urban design with health-based approaches (Rahimifard, 2015; Hakimian, 2014; Razaghi Asl, Alimardani & Zibaie 2014). Meanwhile, some of these studies have also focused on the neighborhood scale (Shieh, Zarabadi & Yazdanpanahi, 2012).

B) Studies conducted on the significance of the relationship between physical activity and walkability of the built environment: studies indicate that most of the urban design research considers physical activity and walking behavior as one of the factors influencing physical health, and the relationship between them has been investigated in that way (Moudon, Lee, Cheadle, Garvin, Johnson, Schmid, Weathers & Lin 2006; Cutumisu, 2011, Buck, 2015). Particularly in this field, studies have been conducted on the relationship between the form of the environment and people's tendency to walking and physical activity (Feng, Glass, Curriero, Stewart, & Schwartz, 2010; Forsyth, Michael Oakes, Lee, & Schmitz, 2009; Giles-Corti, Kelty, Zubrick, & Villanueva, 2009; Susan L. Handy, Boarnet, Ewing, & Killingsworth, 2002; Papas, Alberg, Ewing, Helzlsouer, Gary & Klassen, 2007). The results of these studies generally show that the health and amount of physical activity in the urban environment is not only influenced by personal characteristics (such as age, gender, psychological traits, etc.) but is also affected by the environment that individual lives and works in. In other words, physical and environmental components are also influential in this regard and the built environment can promote or limit physical activity by creating a supportive space. Meanwhile, some relevant domestic studies have been also conducted in this field. For instance, some of the studies have sought to identify the suitable criteria for pedestrian zones (Rikhtegaran, Nouri & Bakhtiar, 2020; Nikpour, Hosainpout & Talebi, 2017; Bahraini & Khosravi, 2010). Another group of studies has investigated the impact of physical factors on the amount of pedestrian activity particularly (Sedigh, Lotfi & Ghadami, 2016; Kazemi & Gol Laleh). Other studies have examined the influence of walking and the respective design criteria on health (Ghafarian Shojaei, Noghsan Mohammadi & Tajdar 2013).

Reviewing the conducted studies shows that the built environment has been used generically to investigate the influence of urban form on physical activity and walkability; hence, the urban form and morphology literature has been less addressed in these studies. However, studies that have adopted space syntax as their technique have paid more attention to physical configuration based on the viewpoints of the social logic of space theorists and the influence of other physical form elements have been less emphasized. Meanwhile, form analysis methods have not been used much to investigate the significance of the relationship between the two research variables. The emphasis on the scale of the neighborhood as opposed to urban space beside the development of physical form design guidelines for local pathways is the innovation of the present study.

Table 1

3. Theoretical Framework

3.1. Urban form and its elements

There are many definitions for the urban form. Regarding its complex nature, different experts have addressed it from a variety of perspectives. Some believe that form, in addition to the physical elements, includes the activities, flows, and urban movement systems, and potential urban events with all material and immaterial appearances. Therefore, urban form is the result of the interaction among the factors of building form, including the physical factors, natural, and human factors (Habib, 2006). Karl Kropf (2009) states that the general aspects of urban form are the spatial relationships between physical aspects (site and artifact form), human interactions, and physical aspects (social and economic context, performance, designer, perception), as well as resource flow and time communications.

Based on the urban physical form in this article, some of the definitions are presented. Kevin Lynch (1981) regards the urban form as visible and physical appearances. Muratori defines the urban form and structure as the result of opinions, preferences, movements, and actions which are manifested in the form of buildings and spaces (gardens and streets). The mass and space as the built urbanscape can be categorized in different types with different characters (Jamali, 2012).

Regardless of the definitions provided for the urban form, the elements of urban physical form are assessed by different theorists. In the Conzen view as the initiator of the morphology study, the elements of the form are the street, parcel patterns, buildings, and land use (Conzen, 1960). Oliveira considers the streets, urban blocks, parcels, and buildings as the main elements of urban form (Oliveira, 2016). According to Jenks and Jones (2010), size, shape, scale, density, land use, types of building, urban block syntaxes, and distributing green space are elements of the physical form. Based on other scholars, the elements of form include the parcel, property size, street orientation, tree and canopy size, configuration, and vegetation (Ko & Radke, 2014). Saeed Nia (2000) believes that the elements of urban physical form, which are the result of socio-economic forces in the form of the political, military, architecture, and engineering decisions, are considered as the physical patterns. These patterns include connection network (access), urban center pattern, urban green spaces pattern, density pattern, parcels, urban fabrics (fine and coarse grain), and mass and space pattern. Furthermore, the patterns in the micro-scale in which the details of architecture and construction are used include the building facade, openness, full and empty spaces in buildings, and covering the roof.

Caniggia and Maffei (2001) define the elements in the urban form as parcel, pertinent strip, street, block, infill fabric, and node and poles. In general, based on different studies, the physical elements of the urban form include the parcel, block, and network, and factors related to the elements are the use, density, permeability, and accessibility (Table 1).

Elements of the physical form of cities based on different theorists

Theorist	Scale	Shape	Size	Nodes & Poles	Base & Infill Tissues	The Pertinent Strip	Permeability	Density	Accessibility	Land Use	Vegetation	Street Network	Lots	Buildings	Blocks
Muratori(1959)											✓	✓		✓	
Conzen (1960)							✓		✓	✓		✓	✓	✓	
Lynch (1981)								✓			✓	✓	✓	✓	✓
SaeedNia (2000)								✓	✓			✓	✓		✓
Caniggia & Maffei (2001)				✓	✓	✓	✓					✓		✓	✓
Habib (2006)											✓	✓		✓	✓
Kropf (2009)					✓				✓				✓	✓	✓
Jenks & Jones (2010)	✓	✓	✓					✓		✓	✓	✓		✓	✓
Ko & Radke (2014)								✓			✓	✓			✓
Oliveira (2016)												✓	✓	✓	✓

3.2. Identifying the form elements affecting the physical activity and walkability

The influence of the physical environment on physical activity and walkability was already explained. Now, the elements of form and urban morphology, and their impact on the dependent variable are evaluated.

Undoubtedly, the social logic of space theory, which was proposed by Bill Hillier and Julian Hanson, is considered as one of the complete theories approving the impact of form and spatial configuration on movement and walkability by providing technique of the space syntax (Hillier & Hanson, 1984). This approach examines human behavior and social activities from the space perspective (Jiang et al., 2000). Based on the approach of social logic, connectivity and visual permeability affects the movement flow of pedestrians more than the land uses. According to Hillier, space permeability is the only variable, which is always correlated with the use of space and movement. Some of the theorists believe that the spatial configuration can be regarded as a major factor in predicting the pedestrian movement (Toker et al., 2005; Koohsari, Oka, Owen & Sugiyama, 2019) as the topological condition has an essential impact on people's movement decisions (O'Neill, 1991).

Regardless of the influence of the spatial configuration on walkability mentioned in various studies, the influence of various physical form factors on physical health, physical activity, and walkability has also been studied. Some of the studies have emphasized some criteria generally. Oliveira, in the book "Urban Morphology: An Introduction to the Study of the Physical Form of Cities", reviews some of the studies conducted on the impact of form on different fields such as social justice, cultural heritage tourism, public health, climate change, and energy and approves that the form affects the public health and physical activity. He explains the physical and forms elements as follows:

- Street connectivity: It is considered as a network of integrated streets and small street blocks (two related components), which is effective in reducing the distance between the source and destination, selecting alternative streets for movement, and reducing the speed of the vehicles.
- Location of the mass in the parcel: The buildings located on the street side and their proximity have a positive impact on walking, while the buildings located on the back to the street side and the parking lot discourage the walking behavior.
- Mix use (Oliveira, 2016).

Another study has considered the interaction between several criteria to influence the amount of physical activity. These criteria include residential density, the number of intersections, mixed land-use, and access to recreational and commercial spaces (Frank, Kerr, Chapman &Sallis, 2007; Vojnovic, Jackson-Elmoore, Cynthia, Holtrop & Bruch, 2006). Some other studies had a particular emphasis on network features. Based on the research conducted by the National Foundation for the Heart in Australia in support of the walkable environment, the environmental characteristics which lead to increased mobility and activity include street connectivity, the pattern of the network (grid), walkable and safe streets for pedestrian, access to public transportation, and continuity of public services (Lock, 2008: 19). Based on some of the patterns of planning and designing the urban form, reducing street connectivity, low accessibility, lack of proximity, and low diversity result in reducing the amount of physical activity (Lock, 2008: 20). Some studies have emphasized the connectivity criteria (Dill, 2004 Koohsari, Sugiyama, Lamb, Kare& Neville, 2014) and have reported factors such as block length, size, and density, intersection and street density, and grid network as influential factors (Dill, 2004).

The US transportation research board examines the impact of the built environment factors on physical activities and health. Based on the model developed in the study, the individual characteristics are considered as an effective factor in doing physical activity on different scales (building, district, and region). On the building scale, which is regarded as the smallest scale, the physical characteristics of the building (the stairs and interior design) affect the physical activity. On the bigger scale, in the neighborhood, the residential units, retail shopping, commercial services, and educational centers, some characteristics such as the pattern of the streets' network, density, access to the parks and public spaces, continuity, and mix-use affect physical activity. In the urban region, the characteristics such as the area size, the job distribution in the residential area, spatial structure, and access to public transportation affect the level of physical activity (Lock, 2008 Adopted by US Transportation Research Board, 2005).

Significant results have shown the factors affecting walkability, especially those that have examined the impact of urban form on walkability, are presented. Studies conducted so far (Frank, Sallis, Conway, Chapman, Saelens, & Bachman, 2006; Lee & Moudon, 2006) indicate that walkability as a quality is a significant subject in the investigation on the correlation between urban form and physical activity. From Robert Cowan's perspective, walking is the convenience of moving by foot around one area, from one area to another, or from a home to local and services amenities (Cowan, 2009). In addition, walking is defined as ones' capability to move from one urban area to another easily (Sallis, 2009). Leslie et al. (2006) are also on the conviction that the urban characteristics (environmental structure and land use) can motivate residents to walk for leisure, sports, and accessing services or going to work (Moura, Cambra & Goncalves, 2017).

The encouraging factors of pedestrian movement have been investigated from various academic perspectives. From Southworth's perspective, an environment has a significant role in 1) creating pedestrian comfort and security; 2) regulating people's connection to multiple destinations; and 3) having visual qualities that encourage walking (Southworth, 2005). For others, indicators such as street width, number of lanes, safe driving speed, safety at intersections, and green and open spaces are essential factors. However, other factors such as destination, land use, and population indices (such as density) influence walking more than the previous factors (Ewing & Cervero, 2010). Burton claims criteria such as cleanliness, traffic characteristics, and land use have a pivotal impact on walking (Burton, 2005). Cao considers elements like safety, presence of trees and their shadows, beauty, traffic, distance from destination, route comfort, quality of use, and attractiveness that affect walking (Cao, 2006). Others believe factors such as population density, mix-use, access to public transportation, safety, security, connectivity, and the availability of facilities to be influential (De Bourdeau dhuji, 2005). Some assume that proximity to destination, mix-use, residential density, direct route, beauty, and traffic are effective factors (Lee, 2006). Spence considers elements such as mix-use, sidewalk presence, security, recreational regions, beauty, and perceptual network connectivity as playing an important role (Spence, 2006). While some propose factors such as proximity to facilities, diversity inducing density, infrastructure quality, and delicateness (Daniel, 2012), others consider elements including safety, ease of movement, sidewalk presence, navigation, security, beauty, convenience, and route smartness to be influential (Mott, 2012).

In a comprehensive classification, Chris Bradshaw categorizes the effective factors into several general classes including environmental, functional, natural characteristics, etc. Considering the first category, he suggests a foot-friendly environment that has wide sidewalks, small intersections, narrow streets, enough wastebaskets, and suitable lighting, and should lack physical barriers in route. In respect to the second category, Bradshaw believes that an adequate amount of destinations such as malls, service centers, specialized offices, and libraries are necessary for encouraging walking. Regarding natural characteristics, climate factors, air pollution, excess noise, and dirtiness are factors that should be considered (Mantri, 2008: 13). London Planning Advisory Committee mentions the criterion of connectivity, i.e. the concept of interconnected walking networks. Another criterion is the area's vitality and friendliness. Clarity and perceptibility associated with the presence of lighting signs, landmarks, and systems, which leads to higher road security is another factor. Comfort alongside convenience that both result from the quality of pavement, interesting landscape, and traffic control, are two other effective measures (Mantri, 2008: 15).

A survey on studies that have particularly investigated the connection between form and walkability shows that there is a correlation between walking and high density, the number of intersections, mix uses, and closer accessibility to services (Frank et al., 2004; Frank et al., 2005; Lee & Moudon, 2006). Other examples have emphasized some road features such as ease of access to transportation and pathway readability (Liao, Shibata, Ishii, Koohsari, Inoue & Oka, 2018), traffic volume, road slope, road width, safety, and lighting (Owen, Cerin, Leslie, Dutoit, Coffee, Frank, Bauman, Hugo & Saelens Sallis, 2007; Kirtland, Porter, Addy, Neet, Williams, Sharpe, Ne, Kimsey & Ainsworth, 2003; Lin, 2018; Bahraini & Khosravi, 2010 & Kondo, Fluehr, McKeon &Branas, 2018) in addition to the aforementioned three general criteria. Vojnovic et al. (2006) indicate that access, mix use, street connectivity, designing the building, and configuration of the buildings and streets affect the number of pedestrians and physical activities. Frank et al. (2007) have evaluated the relationship between the objectively measured urban form and youth walking. His study results in several effective elements on youth walking, which are the residential density, the number of intersections, mix use, and access to commercial and recreational spaces. Dill (2004) has examined connecting the network of streets and bike

riding. He provides the indices for the network connectivity such as the block length, block size, block density, intersection density, street density, and grid network. Meanwhile, some studies have also discussed the form and type of the blocks and parcels. For instance, indicators such as the depth of the parcels, the width of the street, and block length have been considered influential in the amount of walkability. These studies suggest that smaller blocks and a higher number of connections increase walkability (Dill, 2004; Talen & Koschinsky, 2013). Other studies have emphasized the block and parcel orientation as well as the type of the edge, indicating that the presence of active or passive edges influences walkability (Talen &Koschinsky, 2013). Other parcel-related features such as materials, color, height, and architectural style have also been paid attention to (Lin, 2018; Kondo, Fluehr, McKeon & Branas, 2018). Table 2 shows a summary of what was previously mentioned in this section.

Table 2
Effect of the elements of urban form on walkability from the theorist's perspectives

Theorists	**Effective Elements of Urban Form on Walkability**
Hillier & Hanson (1984); Toker, Baran & Mull (2005); Koohsari, Oka, Owen & Sugiyama (2019); O'Neill (1991)	Spatial Configuration, Integration
Frank, Schmid, Sallis, Chapman & Saelens (2005); Frank, Anderson & Schmid (2004); Moudon, Lee, Cheadle, Garvin, Johnson, Schmid, Weathers & Lin (2006); Sallis (2009); Arvidsson et al. (2012); Tabibian & Mohammadi, 2021	Residential Density, Number of Intersections, Mixed Land Use, Close Access to Services
Dill (2004) ; Talen & Koschinsky (2013)	Block Length, Block Size, Block Density, Intersection Density, Street Density, Grid Pattern Network
Transportation Research Board (2005); Koohsari, Owen, Cole, Mavoa, Oka, Hanibuchi & Sugiyama (2017)	Physical Features of the Building, Street Network Pattern, Residential Density, Access to Parks and Public Spaces, Continuity, Land Mix Use, Size of Area, Distribution of Commence and Population, Spatial Structure, Access to Public Transport
Frank, Kerr, Chapman, & Sallis (2007); Koohsari, Owen, Cole, Mavoa, Oka, Hanibuchi & Sugiyama (2017)	Residential Density, Intersection Density, Mixed Land Use, Access to Commercial and Recreational Spaces
Vojnovic, Jackson-Elmoore, Holtrop, J. & Bruch (2006)	Accessibility, Land Mix Use, Connectivity, Building Design, Building Configuration, Street Space
Spence (2006)	Mix Use, Sidewalk, Security, Recreational Regions, Beauty, Connectivity
London Planning Advisory Committee adopted by Mantri,2008	Connection, Convenience, Comfort, Vitality, Clarity
Australian National Heart Foundation (2008)	Street Connectivity, Grid Pattern Network, Walking Paths, Secure Crossings at Streets, Access to Public Transport, Continuity of Public Services, Proximity Criteria
Frank, Sallis, Saelens, Cain, Conway & Hess (2009); Arvidsson, Eriksson, Lönn & Sundquist (2012); Christiansen, Cerin, Badland, Kerr, Davey, Troelsen, van Dyck, Mitas, Schofield, Sugiyama, Salvo, Sarmiento, Reis, Adams, Frank & Sallis (2016)	Residential Density, Street Network, Land Mix Use
2010 Ewing & Cervero (2010); Lin (2018); Kondo, Fluehr, McKeon & Branas (2018); De Bourdeau dhuji(2005)	Street Width, Transportation Route Presence, Safe Driving Speed, The safety of Intersections, Green and Open Spaces, Presence of Destination in the Path, Presence of Population Density During Path
Mott (2012)	Safety, Ease of Movement, Sidewalk Presence, Navigation, Security, Beauty, Convenience, Route Smartness
Loon & Frank (2011) Talen & Koschinsky (2013); Van Cauwenberg, Nathan, Deforche, Barnett, Barnett & Cerin (2018)	Residential Density, Land Mix Use, Access to Specific Functions, Street Connectivity, Urban Furniture, Trees in the Street, Suitable Lighting
Daniel (2012)	Proximity to Services, Diversity-Inducing Density, Infrastructures Quality, and Delicateness
Oliveira (2016)	Residential Density, Land Mix Use, Access to Specific Functions, Street Connectivity, Urban Furniture, Trees in the Street, Suitable Lighting
Sevtsuk, Kalvo & Ekmekci (2016)	Frontage, Plot depths, Street widths, Block lengths

Assessment of the above literature declares factors that mostly encourage walkability. To present a proper categorization of the indices of urban form elements, what follows can be referred to.

- Indices pertinent to street network: the path width, access to the path, safe driving speed, safety at intersections, path continuity, lack of road barriers, number of intersections, connectivity and coherency, street clarity and perceptibility, visibility, quality of sidewalks,

traffic control, movement ease, navigation, spatial configuration, network pattern, connectivity, intersection density, and paths for walking.

- Indices of blocks: visibility, permeability, residential density, blocks length, block size, and block density.
- Indices related to parcels: parcel architecture, façade, physical features of the building, and the mass position in space.
- Indices pertinent to land use: attractive uses, mix use, access to and green and open spaces and public places, and access to public services
- Other factors: trees and vegetation, population index (population density and individuals presence), furniture (wastebasket), lighting, climate convenience, culture for walking, air and environmental cleanliness, noise comfort, convenience, vitality, comfort, distance to destination, beauty, pleasantness, and smartification.

3.3. Methods of analyzing urban form and its elements

Generally, the methods of analyzing the urban form are based on the views of Moudon (1997) and Karl Kropf (2009), which include historical analysis (based on the English school and Conzen view), typological analysis (based on the Italian school), and spatial configuration (based on the space syntax and Hillier and Hanson views).

The historical analysis method is based on analyzing the map unit in different periods and the trend of changing fabric (Conzen, 1960). In the typological analysis, each object is described as a complex being composed of a set of elements, structures, systems, and organisms (Kropf, 2009), and the typology can be examined at the scale of the parcel, and block. In short, the analysis method of space syntax is considered as a set of computer techniques to model buildings and towns so that a model can be created from a system including geometrical elements and its analysis to understand how to relate the elements. The elements are linear when the research subject is on movement. They are convex spaces when the subject is social interactions.

Additionally, the elements are visible areas when the subject is intricate behavior patterns. The space syntax method is considered as a way to understand the spatial configuration so that the social logic factors can be identified (Hillier & Vaughan, 2007). The research direction of Karl Kropf (2009) is described as an acceptable method in the study. In fact, in his view, the main challenge is combining the different approaches for examining the form, such as the spatial analysis (cellular automata), spatial configuration, typology, and historical-geographical approach. Vitor Oliveira introduces the methods by using Kropf research direction and four approaches for studying Porto in his book (Oliveira, 2016). The present study simultaneously combines the configuration and typology methods by adopting the Kropf approach (Table 3).

Table 3
A comparison of the analysis methods for physical urban form

Method Name	Theorists	Factors studied
Historical-Geographical (Based on Map unit)	Conzen	Town Map (Streets and their System, Parcels and their Arrangement in the Blocks, Block Design), Building Fabric, and Land Use
Typology	Muratori & Caniggia	Elements (Buildings), Constructing Elements (Urban Fabric), Construction Systems, and System Organism (Urban Areas)
Spatial Configuration	Hillier & Hanson	Spatial Configuration, Natural Movement, and Integration
Mixed-Method	Kropf	Combining Previous Methods and Spatial Analysis

3.4. Conceptual Framework

In this section, an inference is conducted by the reviewed studies, and a model is accordingly developed. This application in the two neighborhoods contributes to examining the research questions. The following is a summary of the physical form elements and their indices that influence walkability. Some of the indices presented are absent in previous studies and are summarized by the authors' views (Table 4).

Table 4
A conceptual framework for research

Elements of Urban Form	Factors	Sub-Factor
Street Network	The Pattern of Network Streets (Lock, 2008)	The Grid Pattern, Deformed Pattern (Koohsari, Oka, Owen & Sugiyama, 2019)
	Physical Characteristics of Streets	Street Width (Frank, Schmid, Sallis, Chapman & Saelens, 2005) (Ewing & Cervero, 2010) (Owen, Cerin, Leslie, Dutoit, Coffee, Frank, Bauman, Hugo & Saelens Sallis, 2007) (Kirtland, Porter, Addy, Neet, Williams, Sharpe, Ne, Kimsey & Ainsworth, 2003) (Talen & Koschinsky, 2013)
		Street Length (Sallis, 2009)
		Number of Intersections (Frank, Schmid, Sallis, Chapman & Saelen, 2005)
		Intersection Shapes (Hillier & Hanson, 1984)
	Quality Characteristics of Streets	Street Continuity (Oliviera, 2016) (London Planning Advisory

		Committee) (Spence, 2006) (Koohsari, Sugiyama, Lamb, Kare & Neville, 2014) (Vojnovic et al., 2007) (Liao, Shibata, Ishii, Koohsari, Inoue & Oka, 2018)
		Street Connectivity (Oliveira, 2016) (London Planning Advisory Committee) (Spence, 2006)
		Integration (Hillier & Hanson, 1984) (Toker, Baran & Mull, 2005); (Koohsari, Oka, Owen & Sugiyama, 2019); (O'Neill, 1991)
		Street Facade (Humpel, Owen & Leslie, 2002) (Lin, 2018) (Bahraini & Khosravi, 2010) (Kondo, Fluehr, McKeon & Branas, 2018)
		Clarity & Way Finding (London Planning Advisory Committee) (Walkonomics, 2011) (Liao, Shibata, Ishii, Koohsari, Inoue & Oka, 2018) (Mott, 2012)
		Link to Travel Destination (Southworth, 2005) (Ewing & Cervero, 2010) (Lin, 2018) (Bahraini & Khosravi, 2010); (Kondo, Fluehr, McKeon & Branas, 2018); (Koohsari, Owen, Cole, Mavoa, Oka, Hanibuchi & Sugiyama, 2017)
		Accessibility to the Street (Ewing & Cervero, 2010)
	Street Density	Building Density at the Intersection (Kaplan, Sick, Nielsen & Parto, 2016)
		Building Density on the Street Edge (Liao, Shibata, Ishii, Koohsari, Inoue & Oka, 2018)
Block	Block Pattern (Dill, 2004); (Talen & Koschinsky, 2013)	Regular, Irregular
	Active and Non-Active Edge in the Block (Carmona, Heat, Oc & Tiesdell, 2003) (Talen & Koschinsky, 2013)	The Existence of Attractive Uses for Population, Non-Permeability Walls or Lack of Permeability of Edge
	Block Shape	Regular, Irregular Courtyard Block, Blocks Facing the Street
	Block Density (Dill, 2004)	Building Density, Mass-space Ratio
	Block Size (Dill, 2004) (Talen & Koschinsky, 2013)	Small, Medium, and Large
Parcel	Parcel Shape	Regular, Irregular
	Parcel Size (Vojnovic, Jackson-Elmoore, Holtrop & Bruch, 2007)	Fine-Grained, Medium-Grained, and Coarse-Grained
	Building Density of the Parcel) Talen & Koschinsky, 2013) (Liao, Shibata, Ishii, Koohsari, Inoue & Oka, 2018)	Low, Medium, and High
	Building Position on the Parcel (Oliviera, 2016)	Mass in the Street Proximity, Space in the Street Proximity
Land Use	Mix use (Sallis, 2009) (De Bourdeau dhuji, 2005) (Zhao & Wan, 2020)	A Variety of Uses/Lack of Functional Variety
	Access to the Specific Uses (De Bourdeau dhuji, 2005) (Frank, Kerr, Chapman,& Sallis, 2007) (Koohsari, Owen, Cole, Mavoa, Oka, Hanibuchi & Sugiyama, 2017)	Green Uses, Daily Uses, Recreational Uses, Commercial Uses, and the Like
	Use Scale (Carmona, Heat, Oc & Tiesdell, 2003	Local Uses, Global Uses
	Compatibility of Uses	Local Compatibility/Incompatibility Use Leading to Pollution and Noise
	Type (Cao, 2006)	Attractive Land Use (Burton, 2005), Residential Land Use (De Bourdeau dhuji, 2005), Services (Daniel, 2012); (Parks Christiansen, Cerin, Badland, Kerr, Davey, Troelsen, van Dyck, Mitas, Schofield, Sugiyama, Salvo, Sarmiento, Reis, Adams, Frank & Sallis, 2016) (Van Cauwenberg, Nathan, Deforche, Barnett, Barnett & Cerin, 2018) (Kheirkhah & Nemati Mehr, 2021)
Other Factors	Functional	Street Furniture (Loon & Frank, 2011), Quality of Infrastructure (Daniel, 2012)
	Environmental & Natural	Vegetation (Chris Bradshaw) (Cao, 2006) (Ewing & Cervero, 2010)
	Visual	Aesthetics & Visual Attractiveness (Southworth, 2005) (Cao, 2006) (Spence, 2006) (Mott, 2012)
	Cultural	Culture of Walkability (Chris Bradshaw)

The importance of influencing the physical form elements on walkability is identified. The network pattern is considered as the first layer in analyzing the extent of walking. From a space syntax perspective, the configuration is regarded as the most crucial factor influencing the movement pattern. This layer is evaluated since the fabric permeability, and accessibility is affected by the blocking pattern. In addition, the pattern of land use and parcels are explored. According to the authors, reviewing the above process alone is not sufficient, and the opinions of space users should be reviewed to verify the results. Finally, the characteristics of urban form elements that encourage walkability at the neighborhood scale can be identified by adopting objective and subjective reviews.

4. Research Methodology

As previously mentioned in the urban form analysis methods, the research method of the present study is based on mixed techniques of form analysis. The order of form layers analysis was determined according to what has been mentioned in the conceptual framework section. Plans are from analysis units at various levels; therefore, the updated plans were obtained by referring to the reference organizations and the validation was ensured through a field survey.

- The Depth Map software as well as axial and segmental maps are used to analyze the network system and the spatial configuration for form analysis. Segmental maps analyze urban texture and each segment addresses one axial line to provide more accurate results. Results of this section present which paths have the most integration and which have the most natural movement flow. According to the results of these maps, the pathways that are mostly used according to this method are selected. Since one cannot merely rely on software analysis, the segments that had higher numbers of integration according to software were examined through field survey (observation and interview) so that other influential formal elements in the area can be studied at the next stage. For validating the selected zones, behavioral patterns were studied in three patterns of walking, sitting, and standing in the space through a field survey.
- In the typology study of the two elements of block and parcel, the map analysis unit, as well as export-oriented and qualitative methods, were used. In other words, the physical characteristic of these elements was identified due to the higher presence of people in these parts of the pathway.
- In the study of the most inconstant urban morphology element, data on the land use and activities of zones were collected through field survey and were then analyzed using the qualitative method.
- To ensure the accuracy of results obtained through the subjective method, space users were asked about the physical elements that influenced their presence most. For this purpose, the physical factors influencing the activity of walking were questioned in both neighborhoods through interviews, and the collected data were then coded and analyzed. The number of interviewees was 25 people in the Haft Hoz neighborhood and 22 people in the Bagh-e-Feyz neighborhood. The sample size was determined based on data saturation.
- Results of the subjective and objective methods were eventually integrated to develop the urban design guidelines for local pathways suitable for walking and physical activity in neighborhoods with an emphasis on physical form elements.

5. Results and Discussion

In this part, two cases are selected based on their morphological difference for examining the questions of this research. As mentioned before, the main issue is related to the influence of spatial configuration and other form elements on pedestrian movement and walkability. In the following parts, step by step, the influence of this factor and other factors is examined to compare the results in two different fabrics and the conclusion is finally conducted based on the results.

5.1. Step One: Selecting and over viewing case studies

Given that the research subject was to examine the relationship of physical and formal neighborhood elements with the amount of physical activity and walkability, efforts were paid so that two neighborhoods with different urban forms were selected assuming that the economic, social, and environmental factors were the same in both neighborhoods. Narmak neighborhood in the north-east of Tehran is one of the first modern urban planning experiences in Iran with a grid network while the Bagh-e-Feyz neighborhood in the north-west of Tehran has an organic urban texture and a rural core. Besides, another factor influencing the selection of the two neighborhoods of Haft Hoz and Bagh-e-Feyz was the non-dominance of automobiles in these neighborhoods. For instance, in similar neighborhoods with grid networks (e.g. Shahrka-e Gharb) or organic urban texture (Zargandeh), insufficient attention has been paid to pedestrian activity due to the high economic status of the residents; hence, people mostly use automobiles to move around. The culture of using public spaces as tools and walking destinations exists in the case studies of the present study, and residents tend to walk around the neighborhood to do their daily activities.

- Haft Hoz, (Figure 1) a grid neighborhood (located in central Narmak, Region 8 of Tehran Municipality and District 2): Narmak is considered as one of the first grid settlements with a hierarchy. The neighborhood is bounded on the north by Resalat highway, on the south by Shahid Sani Street, on the east by Dr. Ayat Boulevard, and on the west by Samangan Street. The most prominent morphological features of the neighborhood are as follows: The regular

pattern is regarded as the most obvious type of grid in which the blocks are regular and square-rectangular. The neighborhood is set in the square-street grid pattern. Based on the land use map, residential use is dominant and is followed by the transportation and storage, commercial spaces, green spaces, urban, religious, industrial, and military services, respectively. Based on the map of the number of floors in the neighborhood, four to six buildings have the largest share. Based on the building density, the 180-240% (average density) has the largest share, followed by 240-300%. Based on the grading of the aggregates, a large number of parcels are less than 200 square meters; therefore, there are fine-grained and medium-grained parcels.

- Bagh-e-Feyz (Figure 2), as an organic neighborhood (located in the eastern boundary of Region 5 of Tehran Municipality and District 3): The neighborhood goes north to Hemmat highway, east to Ashrafi Isfahani highway, and south to Hakim highway, and west to Sattari highway. The neighborhood has long been regarded as one of the old villages in Tehran. The original residential and rural core was shaped in the eastern part and around Khatun and Ja'far Imamzadegan and was organically developed. The present study analyzes the eastern Bagh-e-Feyz (about 100 Hectares) where its organic structure was retained. The morphological features in the neighborhood are as follows:

  Based on the street network, the organic neighborhood has a hierarchical system with low width and winding paths and cul-de-sacs. In addition, the network has irregularly and large urban blocks. After residential use, the most significant shares in land use belong to transportation and storage, commercial and office, agricultural, leftover and non-constructed land, green spaces, urban, industrial, and military services, respectively. In terms of building density, the density of 120-180% has the largest share, and the neighborhood has a low building density. In terms of grading the aggregates from fine-grained to coarse-grained, the area of parcels is generally less than 100 square meters, and the neighborhood has a compact fabric with fine-grained parcels.

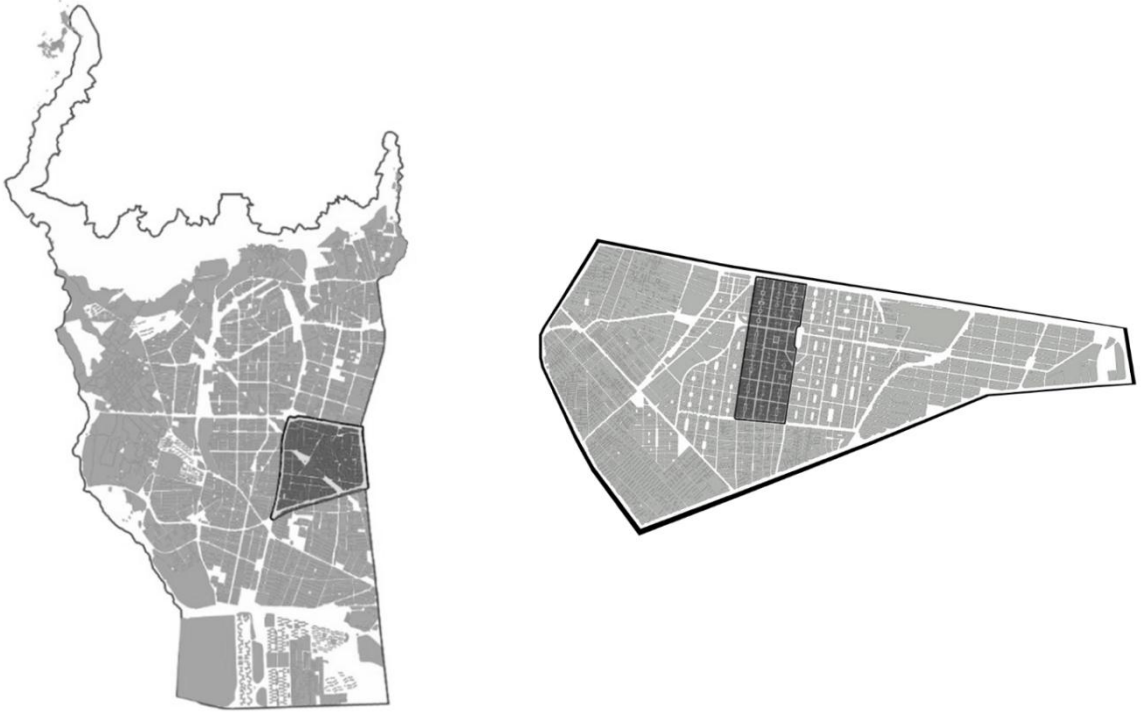

Fig. 1 and 2. Haft Hoz neighborhood in 8th district of Tehran (Left), Bagh-e-Feyz neighborhood in 5th district of Tehran (Right)

5.2. Step Two: Data Analysis

5.2.1. Identifying potential streets for walking in the neighborhoods: Analyzing spatial configuration

To identify the potential areas for walking, the first layer of the conceptual framework (the spatial configuration) was analyzed based on axial and segment maps, and the zones were checked by visibility, and trace analysis indices. Based on analyzing the integration index, the streets, including a large number of the integrities with more walkability, were observed. Analyzing the visibility is considered as an effective confirmation index in choosing the streets for walking.

Since the purpose is to analyze urban fabric, it is not confined to axial map analysis. Segment map, which represents a model of the urban fabric, has been investigated. The segment map depicts urban form thoroughly and since the scope of this study is the zones along the main street of the neighborhood, this map offers

more benefits. This map can be derived from an axial map by segmenting each axial line at every intersection. In this respect, the model comprises a unit for every smallest measurable element of the urban form. For example, the street segment is selected from junction to junction or from a road's bend to another road's bend. The outcome of this map indicates which segments of a single axial line possess high connectivity. Hence, this map guarantees the accuracy of zone selection. Accordingly, areas with the highest potential and capability to be used and pedestrian motion are identified throughout the neighborhoods.

- Results of analyzing spatial configuration indices in Haft Hoz: Both axial (Figure 3) and segment (Figure 5) maps were used to identify potential areas for walking. Based on the results, Azadeh Street (between 70-77 squares with a length of 567m), Bakhtiari, and West Janbazan streets have the highest integration and potential for pedestrian movement. Furthermore, based on the grid pattern in the Haft Hoz neighborhood (Square-Streets), the local squares have high spatial integration and potential for pedestrian movement including 71 and 73 squares have the highest integration. Based on the segment map, zones 1 and 2 in Azadeh Street, and zone 3 in West Golbarg have more connectivity.
  Visibility was analyzed because selecting a street for walking is related to its visibility. The results indicated that Bakhtiari, Azadeh, and West Janbazan have the highest visibility and are most commonly used by pedestrians. In addition, the intersections at these traces or local squares have high visibility. The 70-77, 53-56, and 60 squares have the highest visibility and utility for users.
  In the next step, the patterns of natural moving and individual choice were investigated by using trace analysis. The Azadeh, Bakhtiari, West Janbazan, Mehregan, and Komeyjani, as well as local squares, have a high potential for moving the pedestrians. Accordingly, 73, 62, and 51 squares have the highest movement and use.
  Finally, based on the results, the three linear zones were identified with the most potential and the ability to drive pedestrian traffic at the neighborhood level. The position of the zones is illustrated in Figures 3-6.
- The result of analyzing spatial configuration indices in the Bagh-e-Feyz neighborhood: The axial (Figure 4) and segment maps analysis show that Bahonar, Amir Ebrahim, and Nateq Noori streets have the most integration and potential for walking. Since the main street of each neighborhood is necessary for this study, Nateq Noori, with a lower numeric value of integration in comparison to the other two streets, is selected. Through segment map analysis, the zones with more connectivity with the neighborhood texture are defined. Based on the visibility analysis, Nateq Noori and two other streets named Amir Ebrahim and 22 Bahman have the highest visibility.
  Based on trace analysis, Bahonar, Amir Ebrahim, Nateq Noori, and Mufateh streets have a high potential for pedestrian presence and movement. Bahman 22 and Nateq Noori streets have a high potential for walking because of the unconventional and organic spaces.

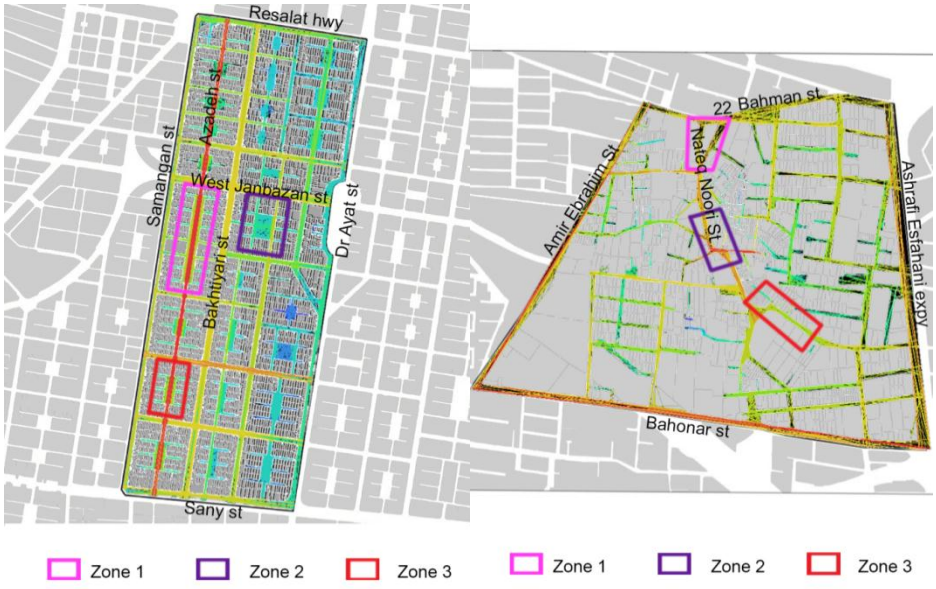

Fig. 3 and 4. The result of the axial map in Haft Hoz (Left), Bagh-e-Feyz (Right), and the location of suitable walking zones

Fig. 5 and 6. The result of the segment map in Haft Hoz (Left), Bagh-e-Feyz (Right), and the location of suitable walking zones

5.2.2. Selecting desirable linear zones

To select the linear zones, the status of the streets was examined by using expert analyses based on the conceptual framework. Then, the desirable zone for morphological analyses was selected by interviewing the residents. The results are as follows:

- Assessing the potential streets for walking in Haft Hoz: The field survey and observation of the streets confirm the previous findings. Azadeh, Bakhtiari, and West Janbazan streets have a high potential for walking because of the factors such as proper width of sidewalks, lack of physical obstacles on the sidewalks, integration on the sidewalks, vegetation on the sidewalks, providing adequate lighting, multiple intersections, and low distance between intersections, harmony, and proportionality, mix use, different pavements in the streets, and favorable visual facade of buildings.
- Assessing the status of the potential streets for walking in Bagh-e-Feyz: Bahonar and Amir Ebrahim streets have a high potential for walking due to the spatial and functional desirability. They are relatively consistent with the indices proposed in the conceptual framework. Nateq Noori, the main street in the neighborhood, is devoid of high quality in terms of presenting factors and is in an inappropriate condition in many indices. However, based on observations, the trace is frequently used for walking due to being a part of the main structure and the physical elements around it. In addition, this street is considered as the only primary access where it connects all parts of the neighborhood (Table 5).

Table 5
Studying the characteristics of potential streets in both neighborhoods comparatively

Index	**Haft Hoz Neighborhood**			**Bagh-e-Feyz Neighborhood**		
	Azadeh St	**Bakhtiyari St**	**West Janbazan St**	**Bahonar St**	**Amir Ebrahim St**	**Nateq Noori St**
Street Width	Walkway Width: 4.5 Meters	Walkway Width: 5 Meters	Walkway Width: 6.5 Meters	Walkway Width: 2.5 Meters	Walkway Width: 2.5-3 Meters	Inappropriate Width and the Lack of Walkway in Some Areas/ Walkway Width: 1-1.5 Meters
Street Length	Total Length: 567 Meters/ The length of the street in each section is 100-200 meters.	Total Length: 1707 Meters/ The length of the street in each section is 100-200 meters.	Total Length: 1710 Meters/ The length of the street in each section is 50-100 meters.	Total Length: 1630 Meters/ The length of the street in each section is 200-300 meters.	Total Length: 1600 Meters/ The length of the street in each section is 300-350 meters.	Total Length: 1100 Meters/ The length of the street in each section is 150-200 meters.
Number of	10	11	6	9	5	7

Intersections	Intersections	Intersections	Intersections	Intersections	Intersections	Intersections
Shape of Intersections	Regular and Four-way Intersections		Regular, Three-way, and Four-way Intersections		Irregular Two-way and Four-way Intersections	Irregular Intersections in the Form of Two-Way, Three-Way, and Four-Way
Street Continuity	Continuity and Integration in Walkways					Lack of Continuity in Walkways
Street Facade	Aesthetically and Visually Quality Building Façade		Exquisite, Beautiful, Detailed Building Facades on the Ground Floor	Proportional and Quality Building Facades in New Developments and Unfinished Building Facades in Old Buildings		Lack of Quality Building Facades and Old Buildings Lack of Facade
Residential Density at the Intersection	Medium and Relatively High Density at Intersections		Moderately High Density at Intersections on the Street	Medium and Relatively High Density at Intersections on the Street		Low Density at Intersections on the Street, and Some Intersections Lack of Facade
Build Density in Street Edge	Moderate Densities in the Street Edge		Moderate and Relatively High Densities in the Street Edge			Low and Medium Densities in the Street Edge

In the third phase, interviews were conducted with the users (residents and pedestrians) to identify an area with the highest use for walking in the neighborhood from users' and residents' perspectives.

- The users' view about walkable zones and their characteristics in Haft Hoz: According to respondents (25 people in linear zone 1, 26 in linear zone 2, and 21 in linear zone 3), the following criteria were identified as the factors affecting the selection of the 73 square (zone 1 with 436.2m length) for the walking, preventing the traffic of motor vehicles, having good quality in sidewalks, facilitating the access and commuting, having appropriate urban furniture, climate welfare, and favorable green space, environmental security, proper lighting in streets and squares, the low wasteland, and the deserted buildings in the zone, aesthetics and environments, cleanliness, access to daily uses, and facilitating the physically disabled.
- The users' view about walkable zones and their characteristics in Bagh-e-Feyz: According to respondents in this neighborhood (18 people in zone 1, 22 in zone 2, and 16 in zone 3) were identified other criteria addition to common criteria with Haft Hoz such as access to religious use, lack of noisy and polluting use, access to neighborhood parks, and presence of residents. Accordingly, the two zones were selected by space users for walking. However, the two zones were assessed relatively well compared to the Haft Hoz. Therefore, the intersection of the two zones on Nateq Noori Street, 405.2 M in length, is the most common place used for walking.

Table 6 elucidates walking incentives according to residents in terms of form elements and other factors. Simultaneously, each factor's frequency in the triple spectrum (high, medium, and low) and its importance concerning both men and women are also presented. The walking indices are approximately similar between the two neighborhoods while the presence of some uses or form elements in the two neighborhoods varies.

Table 6
Factors affecting walkability according to residents

Elements	Characteristics	Frequency	Importance for Men and Women	Characteristics	Frequency	Importance for Men and Women
Street Network	No Traffic of Vehicles	High	Women	Low Vehicle Presence	High	Women
	Quality of Sidewalks	High	Women	Feeling of Security	Medium	Women
	Proper Width	High	Women	Relatively Good Quality of Sidewalks	High	Women
	Ease of Access	High	Nearly Equal	Appropriate Width of Sidewalks	High	Women
	Presence of Field Space on the Path	Medium	Nearly Equal	Ease of Access and Mobility	High	Nearly Equal
Block &	Beauty	High	Women	Relative Beauty	Medium	Women

Parcel	Buildings' Proper Façade	Medium	Women			
Land Use	Low Deserted Lands	Medium	Nearly Equal	Access to Daily Uses	High	Women
	The Absence of Abandoned Buildings	Medium	Women	Imamzadeh Availability	High	Women
	Local Uses	High	Nearly Equal	Proper Access to Local Parks	High	Nearly Equal
	Green Space	High	Nearly Equal	Absence of Disturbing and Noisy Uses	Medium	Women
Other Factors	Absence of Noise and Air Pollution	Medium	Women	Security	High	Women
	Environment Cleanliness	Medium	Women	Optimum Green Space	Medium	Nearly Equal
	Suitability for the Disabled	Low	Nearly Equal	Proper Lighting	Medium	Women
	Urban Furniture	High	Women	The Presence of Residents	High	Women
	Green Space	High	Nearly Equal	People to Attend Imamzadeh	Medium	Nearly Equal
	Lighting and Illumination	Medium	Women			
	Security and Presence of Other People	Medium	Women			

5.2.3. Analysis of users' behavioral patterns in zones

To ensure the correctness of study area selection, the space users' behavioral patterns were investigated across all zones through observation. Various examined behaviors during the day and evening include standing, walking, and sitting in the space (Figures 7 & 8). Field observation of zones in Haft Hoz neighborhood revealed a high walkability potential for people in various age and gender groups in local squares 71, 73, and 62 due to the streets not being arterial, the use of urban furniture, climatic comfort due to the green space, urban facilities, and high security and safety. Analysis of behavioral patterns in zone 1 (square 73) indicated that among these three squares, square 73 had the highest public presence and behavioral pattern diversity due to its largeness, better accessibility, suitable landscaping, and the existence of public gathering spaces. Zone 2 which was located near zone 1 also indicated a higher public presence and behavioral pattern diversity compared to zone 3 due to its larger spaces and land-use diversity.

Studies conducted on Bagh-e-Feyz neighborhood present that although space quality is not as high as Haft Hoz, in this neighborhood, zone 1 is more used by pedestrians out of the three proposed zones due to its favorable accessibility, presence of a park, Imamzadeh, and public spaces. Besides, zone 2 which coincides with a local square is also used by residents because of its favorable sidewalk width, incorporation of stairs and ramps n the pedestrian pathway, access to daily land-uses, and climatic comfort. However, zone 3 is less used by pedestrians due to the lack of sidewalks along the main path, the presence of incompatible land-use (repair shops), and the lack of climatic comfort. The study of behavioral patterns in these three zones indicated that a higher diversity of behavioral patterns was observed in zones 1 and 2 due to their favorable accessibility and their position in the main structure of the neighborhood, the presence of diverse land-use, good access to local parks, and the physical state of their sidewalk which were in a better shape compared to zone 3.

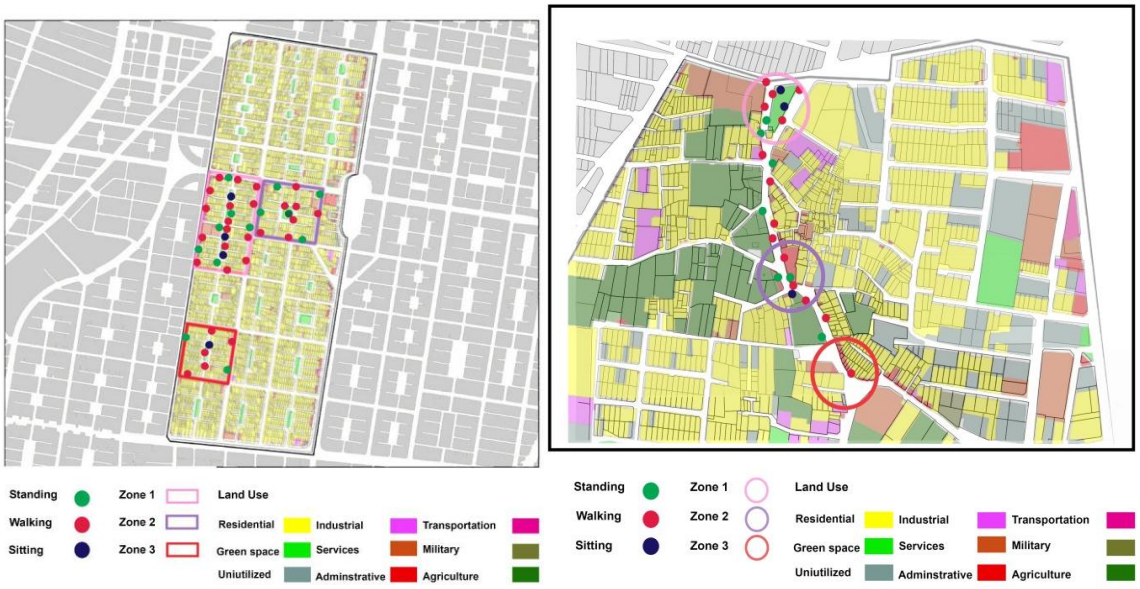

Fig. 7 and 8. Behavioral map in Haft Hoz (Left), Bagh-e-Feyz (Right)

Finally, based on overlapping the results of segment maps, expert-based surveys, and the pedestrians' desirability, the zones were selected for the morphological analysis. In Haft Hoz neighborhood, zone 1, named square 73, was selected for analysis and two zones (1and 2) in Bagh-e-Feyz with the same priority for users were selected. As it can be seen in the table, zone 3 in this neighborhood has more connectivity but based on observation and users' interviews, zone 1 and 2 are more walkable as a result of land uses and proximity to the local square and Imamzadeh (Table 7).

Table 7
The characteristics of potential zones for walkability in both neighborhoods based on expert and users based analysis

Neighborhood	Streets Name	Axial Map	Segment Map		User's Priority	Selected Zone
		The Numeric Value of Integration	The Numeric Value of Connectivity	Segment Length		
Haft Hoz	Azadeh	7.25	Zone 1: 13.09	436.2	1	☑ Square 73
			Zone 2: 7.55	171.1	2	-
	Bakhtiyari	6.69	-	-		-
	West Janbazan	6.45	-	-		-
	West Golbarg	4.09	Zone 3: 8.63	428.2	3	-
Bagh-e-Feyz	Nateq Noori	2.80	Zone 1: 3.03	256.5	1	☑ Zone of Imamzadeh
			Zone 2: 3.24	148.7	1	☑ Zone of Local Square
			Zone 3: 4.65	145.4	2	-
	Amir Abrahim	3.09	-	-		-
	Bahonar	3.32	-	-		-

5.2.4. Typological analysis of the blocks and parcels

In this section, the physical analysis of the immediate blocks in zones and parcels is presented based on the typological method. The results indicate the morphological characteristics of preferred blocks for walking. Based on the resources, small blocks and active edges in blocks can affect walkability. The criteria for analyzing the block typology based on the conceptual framework include the block pattern, active or inactive edge in the block, block shape, block density, block size, and some shape and quantification parameters such as block area, orientation, dimensions, and proportions.

- Typological analysis of blocks and parcels in Haft Hoz: In general, four types of blocks were analyzed. Based on the results, efficient types have regular and rectangular shapes and high permeability. Furthermore, the preferred block pattern is considered as the infill block-oriented towards the local square (courtyard blocks). The medium-grained and fine-grained blocks, while being more accessible, are more desirable due to the deployment in the daily uses and active edges. The building density in the desirable blocks affecting pedestrian flow is moderate and high.
- Typological analysis of parcels: Morphological study of parcels based on the typological method includes the theoretical basis such as the parcel shape, size, building density, and the position in the parcel, and quantitative and shape parameters like the occupation area, parcel pattern, and the number of floors. The typological examination in the parcels reveals seven different types that encourage walking behavior that are regular, square, and rectangular parcels. They have a north-south extension along the trace in the local square, where the buildings are located in the north of the block and face the street. The fine-grained parcels, which create variety in form and activity, are better than the intermediate and coarse-grained parcels. The appropriate number of floors is 4 to 6. The use and age of the parcel affect the shaping and encouraging physical activity.
- Typological analysis of block and parcel in Bagh-e-Feyz: The selected area was divided into nine block types. Examining the activity situations indicate that the block shape (irregularity) does not affect walkability. However, the block size is regarded as the most crucial factor, as large blocks reduce the permeability. The block extension along the axis and the active edge (deploying the small-scale, daily commercial uses) encourage the people to walk. The large blocks located in the gardens and back on the street, which have passive and blind edges limit walkability. However, the same kind of blocks encourages walkability when they have active edges due to the daily and micro-scale commercial uses. The block building density shows that medium and high density affect the increasing movement behavior.
- Typological analysis of parcels: Typological analysis of parcels in Bagh-e-Feyz indicates that irregular, square, rectangular, and trapezoidal shapes do not affect the pedestrian rate. Thus,

parcel shape is not regarded as a factor. However, the mass position is considered a significant factor. In this regard, the entirely constructed, square, and central courtyard forms are the proper pattern. Furthermore, small and medium-sized parcels have become more attractive due to the form variety. At the same time, the favorable facade, active edge, and the number of middle floors are regarded as other suitable measures to encourage walking.

5.2.5. Evaluating the impact of land use and activity on walkability

According to Conzen (1960), land use is considered as one of the factors in form study includes street, parcel patterns, and buildings. Based on the studies, the use and activity type can be a factor to travel and walk.

- The impact of land use and activity on walking in Haft Hoz: Field surveys of the land use and activity indicate a high diversity of activities in Haft Hoz. Deploying small and daily uses (supermarket, bakery, fruit shop) along with residential and office uses and green space have enriched high activity in the area. In addition, the use of adaptability and deployment desirability, leading to the reduction of the distance to the residential location, and encourage people to walk. In addition, access to public and green spaces plays a significant role in this regard.
- The impact of land use and activity on walking in Bagh-e-Feyz: Based on the results in Bagh-e-Feyz, the neighborhood involves some problems compared to Haft Hoz. Maladaptive uses such as industrial uses are regarded as one of the major problems, which results in reducing walking. The lack of a well-defined green space and limited access to public and green spaces due to low fabric permeability are other functional problems. However, portions of the axis, which have functional diversity and are home to daily and local uses, are regarded as a good platform for walking.

6. Conclusion

This article sought to examine the main street analysis of two neighborhoods, which serves as the first level to encourage residents to walk instead of driving vehicles, thereby identifying incentives for pedestrian movement in urban neighborhoods. Since the majority of studies conducted in this field have generally been concerned with identifying objective and subjective indicators and have not particularly investigated the impact of the elements of urban form on encouragement to move, this part has particularly evaluated the effect of morphological elements on walkability, i.e. spatial configuration has extended the other form elements and their influence on walkability. However, it was not confined to the objective approach, and by taking the mixed-method approach, it attempted to elevate the reliability of findings. Therefore, with a subjective approach, it has identified the other effective factors on walkability on the local scale and particularly on the main street. As this section has an applied nature, it has been finally attempted to develop the principles and guidelines of designing a successful local route that encourages residents to walk.

One of the main parts of the Urban Design Guideline Process as Urban Design Guidance is to conduct theoretical studies, formulate the objectives or design principles, and present guidelines for the form layers. Therefore, according to the theoretical foundations and findings obtained in the previous section, as well as the results of Table 8, common principles that encourage walking in both local streets have been identified. Hence, the principles of designing pedestrian paths at the local scale include the following eight principles. The first four principles relate to the spatial configuration and the physical elements of form. Moreover, the other four principles (which are not related to the form) also influence walking behavior and are identified. For further illustration of the concept, the correlation between each principle with form elements has been provided.

- Customizing with Visibility: This principle is mainly formed through pedestrian network patterns and the formal arrangement of blocks.
- Permeability: This principle concerns the pedestrian network patterns and the size of the blocks.
- Coherency and connectivity: This principle relates to the block form and pedestrian network connection and form and is related to the functional coherency in their edges and facades.
- The principle of clarity and perception: It is related to the pedestrian network pattern.
- The principle of activity and vitality: It is related to the mix and variety use, active edges, façade, and urbanscape and townscape.
- Principle of diversity during coordination: It concerns use diversity, block, and parcel (parcel size, land use, and facade).
- The principle of safety and security: It is pertinent to the pedestrian pattern, blocks size, block edge, and parcel use.
- The principle of visual and functional appeal: It is about parcels and street facades, functional diversity, form diversity, and parcel architecture style and blocking.

Urban design guidelines are the product of the matrix, which considers the design principles and the physical and non-form elements encouraging walking. The presented guidelines in Table 9 form the potential recommendations concerning each element for the realization of the eight principles. These guidelines are subject-specific types (Street Development and Design Guideline) that clarify the design principles. For example, the Urban Design Guideline associated with the street network clarifies the design principles of the streets in the form of design recommendations. Finally, to operate the eight suggested principles, design guidelines that encourage walking

behavior have been defined. These guidelines, as stated earlier in the process of providing guidelines, are based on the theoretical foundations and research results and findings in the case studies.

Table 9
Urban design guideline of elements affecting walkability at the neighborhood scale

Street Network	**Block**
• The creation of public spaces integrated with the street network to promote integration and environment attraction contributes to creating a pausing space while moving • Creating a change in direction leads to visual appeal. • The multiplicity of paths connected to the axis should not reduce the continuity of the path. • Increasing physical and visual permeability in the pedestrian path through regular paths and small and medium blocks • Decreasing driving speed through calming traffic measures such as employing flooring materials that reduce speed or changing the width of passageways. • Assigning proper width for sidewalks which do not hinder movement yet creating pause areas • Decreasing physical barriers through pedestrian ways and creating a pathway for pedestrians. • Eliminating vehicles' marginal parks in pausing areas and streets and allocating the maximum space to pedestrians • Creating four-way intersections of convex intersections which provides proper visibility to pedestrians is suggested • Codifying the terms and conditions of the building facade which enhances edges' visual quality along sidewalks • Intersections' edges should abide by building density to some extent to create sufficient enclosures at intersections. It is proposed to observe 1 to 2 and 1 to 3 enclosures • Elevating building density in passageway edges (up to four floors) enables enhanced social supervision to space from upper floors	• Employment of blocks with an active edge (including user-friendly activities and uses) are suggested • Employment of blocks with a regular shape which in addition to increased visual permeability helps street clarity is recommended • Positioning block elongation along the passageway is recommended to encourage pedestrians to walk alongside visual continuity • Employment of small blocks that allow greater permeability besides spatial variability (block length should be less than 170 meters and preferably 65 to 100 meters). • To perceive the path, the physical arrangement of the blocks along the route is necessary. • Excessively protruded blocks and setbacks reduce user's perception and paths clarity; thus, accidental protruded edges and setbacks should be avoided. • It is not recommended to exploit superblocks along the way if the block is single-use nor has rigid and impermeable edges. • application of superblocks with inactive and inoperative edges is not recommended since they lead to decreased permeability and are not publically attractive
Parcel	**Land Use**
• deploying lands in regular shapes along sidewalks contributes to pedestrian's direction perception • Diversity in parcel sizes leads to diversifying the paths. • In the case of parcels' pattern diversity, it is recommended to maintain harmony in residential density, skyline, and architectural style. • Positioning medium and fine parcels in sidewalks edges are highly recommended since this pattern results in variability and activity of the path. • The number of floors in parcels is recommended to be between 2 to 4. • The occupied side of the parcel is suggested to be a street edge to fulfill the edge's enclosure and activity • Diversifying building types through the color of the materials (preserving the color palette of the street), the variety of materials used, and the distinct and harmonious architectural style contribute to the attraction and, at the same time, harmony.	• Employment of mix-use in the pedestrian sidewalk, which addresses the multiple needs of pedestrians passing the space for optional and social purposes, is recommended. • It is better to assign upper floors to residential purposes so that social supervision would be possible, and the presence of strangers in space would be reduced. • It is suggested to deploy attractive uses such as recreational/service providing uses (cafes, restaurants,) in neighborhood scales, rest and interaction areas (equipped green space), cultural uses, local shopping-related uses along the main pedestrian path. • Uses established along the street are better to be at local use scales so that the presence of strangers would be decreased. • Distributing uses along the path leads to higher discretion and population distribution along the path. • It is proposed that commercial uses be located on the ground and first floors leading to pedestrians' better interaction with the path
Other Factors	

- It is recommended to employ green spaces in the forms of trees planting or flowerboxes alongside passageways.
- The quality of green space is of considerable significance alongside its quantity
- The implementation of non-slip and harmonious flooring materials in the pedestrian path is recommended.
- It is recommended to use a variety of colors and textures on the floor of the path that will help to make the path attractive.
- Sidewalk cleanliness through placing wastebaskets and preserving their quality is recommended
- Creating coherency along the pedestrian way through path flattening
- Providing optimum lighting in a path helps to enhance security and presence.
- Observing proper slope in pedestrian paths which allow access for all users such as women with carriages, the elderly, and the disabled (maximum longitudinal slope of 8% and maximum latitudinal slope of 2%).
- The exploitation of urban furniture suitable with distinct seasons along the pedestrian way, which leads to space functionality such as bench, seats, wastebaskets, is recommended.
- Non-deployment of large-scale or urban-scale land uses in the vicinity of pedestrian pathways, which reduces visual vitality and attractiveness and also attracts strangers
- Elimination of incompatible uses (industrial uses, deserted lands) along the local sidewalks results in less security alongside decreased vitality and activeness
- Elimination of inactive uses like repair shops, storehouses at pedestrian path edges
- Activation and redevelopment of deserted and abandoned land on the street edge are recommended.
- Establishment of uses that are active until late in the night, helping to improve the dynamics of the passageway.

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