ISSN: 2008-5079 / EISSN: 2538-2365
DOI: 10.22034/AAUD.2022.252643.2334

Relationship between Objective and Perceived Criteria of Walkability and Walking Rate with Body Mass Index; Case Study: City of Babol

Seyed Mehdi Khatami[a*] - Mojtaba Shahabi-Shahmiri[b] - Zeinab Akbari[c] - Sasan Roushenas[d]

[a] Assistant Professor of Urban Design, Department of Urban Design and Planning, Faculty of Art, Tarbiat Modares University, Tehran, Iran (Corresponding Author).

[b] Ph.D Candidate of Urban Design and Planning, Faculty of Art, Tarbiat Modares University, Tehran, Iran.

[c] Ph.D Candidate of Urban Design and Planning, Faculty of Architecture and Urban Development, Iran University of Science and Technology, Tehran, Iran.

[d] Ph.D Candidate of Urban Design and Planning, Faculty of Art, Tarbiat Modares University, Tehran, Iran.

Received 13 October 2020; Revised 27 November 2021; Accepted 29 January 2022; Available Online 20 March 2022

ABSTRACT

Most studies that focused on walkability and its effects on physical activity use objective and perceived criteria interchangeably despite their different effects on trip behaviors which could produce contradictory findings. Therefore, the interventions aimed at creating walkable environments cannot leave adequate effects on the level of physical activity and walkability. Thus, this article seeks to investigate the concordance of objective and perceived criteria of walkability in three different textures of the city of Babol to measure their effects on the self-reported walkability rate and body mass index. The research uses a combined method and a concurrent parallel plan, selecting 384 people via the random sampling method. Then, the perceived neighborhood environment where people live was examined by users in terms of three components of accessibility, diversity of uses, and street connectivity using the Neighborhood Environment Walkability Scale (NEWS). To measure the objective walkability in the Milestone Network, the variables of connectivity, depth, and integration were used to analyze the space syntax, while entropy and number of the uses at an 800-meter radius were used to measure the mixed land use. Then, multi-level logistic regression analysis was used to measure the extent to which objective and perceived criteria of walkability rates and body mass index were related. The findings reveal that discordance between peoples' subjective and objective perceptions of neighborhood units can, to a great extent, explain the difference of the relationship between the environment and walkability rate, as the people's greater subjective understanding of neighborhood with lower connectivity and mixed land use could explain the purposeful walkability and recreational probabilities by 42 % 28%, respectively.

Keywords: Walkability, Objective Variables, Perceived Variables, Body Mass Index, Babol.

* E_mail: s.khatami@modares.ac.ir

1. INTRODUCTION

In recent years, many studies have used perceived (Lee & Dean, 2018) and objective (Koohsari et al., 2018) criteria to relate structural characteristics of the environment with walkability or physical activity. Conventionally, interviews and semi-structured questionnaires are used to measure perceived criteria of the structural environment, while more accurate benchmarks or GIS standards are used to measure the objective criteria. In spite of this, many of the studies use perceived and objective criteria interchangeably, while discordance between the perceived and objective environments could leave different impacts on the trip behavior and body activities (Consoli et al., 2020; Peters et al., 2020). Some researchers have demonstrated that people tend to overestimate the distance from the destinations which are close to their areas of residence and to underestimate those distances which are far from their residences (Baldock et al., 2019; McCormack, Cerin, Leslie, Du Toit, & Owen, 2008). Furthermore, an Australian study showed that people's positive understanding of perceived mixed land use and street connectivity could objectively compensate for the neighborhood weaknesses and increase the probability of walkability to get to their intended daily destination (Koohsari et al., 2015). Thus, it is not clear to what extent perceived, and objective criteria evaluate the components the same and to what extent they can be used alternatively. It is not clear either whether or not objective and perceived criteria will explain differences in physical activity indices. Discordance between an objective environment and a perceived environment is another reason which leads to various findings in the structural environment, physical activity, obesity, and associated diseases (Desgeorges et al., 2021).

Herbolsheimer et al. (2020) concluded that individual behavior and physical restraints could change subjective perceptions, and this can, to some extent, explain the discordance between objective and perceived evaluations. As a result, a better understanding of the relationship between the objective and perceived environments and physical activity can greatly contribute to understanding the key mechanism underlying the relationship between the structural environment and behavior and the knowledge of potential interventions (Loh et al., 2020). Despite this, most domestic studies have mostly focused on one of the objective and subjective dimensions. For example, Rezazadeh, Zebardast, and Latifi-Uskouei (2011) reviewed subjective and perceived components affecting residents' walkability in the Chizar Neighborhood of Tehran to emphasize the knowledge of various groups' perceptions and their measures to meet their expectations of the neighborhood space to increase walkability pleasure. In the meantime, other researchers only stress objective dimensions of structural components of walkability in order to measure the mere phenomenon of walkability (Saffari-Rda & Shams, 2017; Kalantar & Shahabiayn, 2018) and to associate it with health components (Bahraini & Khosrawi, 2010; Lotfi & Shakibaei, 2013; Azadi-Ghatar, Meshkini, Rokn Al-Din Eftekhari, Mostafavi & Ahadnejad Roshani, 2017). Thus, there is little knowledge of the extent, effects, and factors contributing to discordance between objective and perceived environments in the country. In sum, the research aims to concentrate on three different textures of the city of Babol in order to investigate the discordance of objective and perceived criteria and their relationship with physical activity. Because Babol is the second most populous city of Mazandaran, it is a key area to be considered a case study.

2. THEORETICAL BASICS AND LITERATURE REVIEW

So far, many studies have been conducted on the relationship between discordance of perceived and objective criteria of neighborhood units and physical activities. These researches have mainly emphasized such characteristics as mixed-use, street connectivity, residential density, aesthetics, safety, and security. Most findings reveal that there is a significant difference between these perceptions and the objective environment t (Kent, Ma. & Mulley, 2017). Ma and Dill (2017) enumerated several methodological challenges to explain these discordances. First, it is difficult to define and objectively measure the environment walkability. For people with various priorities and objectives, walking-specific environmental characteristics also change. Second, GIS criterion errors can negatively affect the link between the objective environment and physical activity. The incomplete recording of the structural environment data, absence of infrastructure size and quality data, and various buffers for the definition of neighborhood units constitute part of these errors. Third, perceived criteria are also subjected to measurement errors and may not accurately reflect the people's understanding of the environment. For example, people may do not interpret the survey questions properly. In addition, understanding the outside world through the five senses is integrated into our cognitive background of the environment (Ma & Dill, 2017). A combination of individual and social factors like gender, social class, local culture, experiences, and personal characteristics may affect this cognitive context and not correspond to the objective reality. Therefore, different people produce different mental maps of the same structural environment and thus behave differently (Loh et al., 2020).

Studies have concluded that there are conflicts between the limits of the neighborhood units defined by the researcher and those of the residents. In addition, the people who live in proximity of each other significantly differ over how to define the spatial dimen-

sion of neighborhood units (Desgeorges, et al., 2021). Therefore, achieving a clear-cut and uniform outcome of the unit seems difficult. For example, Gebel, Bauman & Owen (2009) found that both perceived and objective criteria were independently related with physical activity; but subjective perceptions were more correlated with physical activity than objective criteria. In the meantime, the interventions aimed at improving target groups' perception of the environment will have more potential effects on strengthening physical activity. That said, for them, the highest effects will be achieved when these two criteria do conform (Gebel, Bauman & Owen, 2009).

Gebel et al. (2011) did a study on the city of Adelaide and found that rate of recreational walking of the people who considered their neighborhood's walkability to be lower than the objective level was 24 minutes per week less than those who considered their neighborhood to be more walkable than the objective level (Gebel, Bauman, Sugiyama & Owen, 2011).

Another research in Stockholm concluded that one-third of the people who live in walkable neighborhoods did not have such a perception. This discordance was more noticeable between the elderly and the married. When social-demographic characteristics were modified, it was determined that both subjective and objective walkability could help walking rate and physical activity; however, subjective perception of the environment can increase the rate of purposeful and recreational walking by 6 and 10 minutes per week as compared to the objective environment (Arvidsson, Kawakami, Ohlsson, & Sundquist, 2012).

Confirming the findings of the previous study, Koohsari et al.'s study (2015) in the city of Perth, Australia, showed that the structural environment had little effect on physical activity and walking without strengthening peoples' understanding of the environment. Thus, considering peoples' different perceptions of the walkable neighborhoods, objective criteria cannot be regarded as valid measures to assess popular perceptions (Koohsari et al., 2015). Similar findings in Chicago and Sydney confirmed these findings and found that a combination of perceived criteria for achieving better results on health such as depression to be critical (Kent et al., 2017; Orstad, McDonough, Klenosky, Mattson, & Troped, 2017). Jack & McCormack (2014) did a study on 1875 Canadian people and found that there was a concordance between the objective environment and perceived environment, concluding those who live in walkable neighborhoods have a more positive perception of their own structural neighborhood environment. Furthermore, objective and perceived walkability can affect purposeful walking more than recreational walking (Jack & McCormack, 2014). Shatu, Yigitcanlar, and Bunker (2019) also stress that subjective criteria evaluate different components which objective criteria fail to. Therefore, they are both comparable (Shatu, Yigitcanlar, & Bunker, 2019). On the contrary, Hajna, Dasgupta, Halparin, & Ross's (2003) findings showed that objective criteria, as compared to subjective criteria, were more correlated with walking rate, arguing that the measures aimed at increasing physical activity must take into account both individual and structural perceptions to achieve the highest efficacy (Hajna, Dasgupta, Halparin, & Ross,2003). That said, the use of similar tools in research like the NEWS instrument, physical activity that concentrates on transport and recreational walking, and feasibility of GIS can foster the comparison between the findings and achievement of a uniform outcome of policies.

3. RESEARCH METHOD

The present article is a hybrid research design that uses a concurrent parallel plan. In other words, both quantitative (objective walkability) and qualitative data (perceived walkability) were gathered and separately analyzed. The findings were then compared and interpreted. It was concluded that the findings were consistent with each other[1]. Thus, three different areas of Babol city with different social, economic, and structural characteristics were used, which included historical texture of Hasirforoushan, Panjshanbeh Bazar, Sarhamam, Togh-Darbon, Piralam, which, despite recent construction, have structural elements such as small squares, Hosseinyieh, Dervish chapel, bathroom, and bazaar. The Farhangshahr area is a coherent socio-economic region that conforms with the 80s township development process. With the moderate to high economic texture, the Gol neighborhood, designed in the years prior to the revolution and divided in recent years, has been subjected to broad construction processes, with most villa houses turning into 3-7 story buildings. Sampling in each of the textures was done randomly. Also, because demographic data for each texture were not available, 384 people were selected as the sample size. To facilitate the data gathering, the variables and the items were just centered around two key components of walkability, i.e., street connectivity and mixed-use.

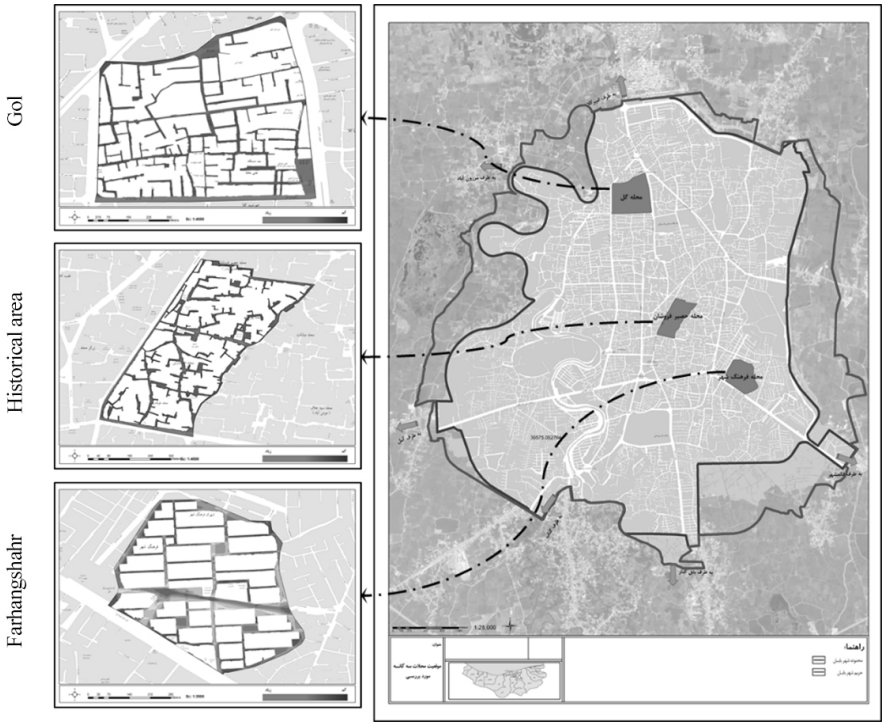

Fig. 1. Location of Case Neighborhoods in the City of Babol

To measure perceived walkability, the Neighborhood Environment Walkability Scale (NEWS) was used (Saelens, Sallis, Black, & Chen, 2003). Hakimian and Lak (2016) introduced a version of the questionnaire in Iran and demonstrated that all the variables and items were enjoying almost full reliability (over 0.8) (Hakimian & Lak, 2016). This questionnaire was categorized based on the respondents' perceptions in 7 components of residential density, use diversity, access to mixed-use, walking/biking facilities, aesthetes, and security. However, this research focuses on three components: 1) diversity-mixed use (walking duration to meet daily needs); 2-access to mixed-use (pedestrian's access to daily destinations), and 3-street connectivity. Each variable is scored from 1-3 on a Likert scale. Then, the sum of scores of each component is categorized into three groups. The scores in the first and third groups are considered to be lower and higher than average rates (Koohsari et al., 2015). Four indices of connectivity, integration, depth, and permeability were used for the objective measurement of street connectivity. The indices of connectivity, integration, and depth of the street network were measured by using the space syntax technique. The criterion of depth is calculated by dividing the street and sum of turns and links each individual must go through to pass from one space to another within the network. The criterion of integration is calculated, unlike the average depth, i.e., integrated streets require fewer turns to get to each other (Hillier, 2009). As well, the space syntax technique also takes into count street accessibility in addition to the density of the intersections. Thus, two local regions of similar intersections may have completely different plans which offer different route options between the source and the destination (Koohsari et al., 2020). Some researchers maintain that these ordinary criteria ignore a large part of the complexity to be investigated (Stangl, 2019). Thus, permeability indices were added to the analyses. To measure permeability, three indices of the mean perimeter of each block, mean area of each block, permeability factor, and weighted mean of the block perimeter were used. , The permeability factor of each urban texture is calculated by dividing the sum of half of the streets and passageways around building blocks by the block areas. As well, the weighted mean of the perimeter of each block is calculated from a sum of products of the area of each block to the total area of the texture in each block perimeter divided by the number of the blocks. This index is mathematically shown as follows:

$$AwaP = \sum_{i=1}^{n} P_i \times \frac{A_i}{A_T}$$

Where n is the number of the blocks, p_i and A_i are the perimeter and area of block i, and A_T is the total area of the blocks. Lower scores suggest more permeability (Pafka & Dovey, 2017). To measure mixed-use, three indices of Shannon entropy, number of non-residential uses, and commercial to residential activities ratio were used. The entropy index is calculated follows:

$$\frac{-\sum (A_{ij} \ln A_{ij})}{\ln N_j}$$

Where A_{ij} is the percentage of land use i in region j and N_j is the number of uses in region j (Manaugh

& Kreider, 2013). The closer we get to 1, the more texture diversity and activity we have.

Perceived criteria were calculated twice. First, they were evaluated to objectively and perceptually compare the neighborhood with each other and the neighborhoods each. Second, the respondents were asked to pinpoint their place of residence on the map when completing the perceived questionnaire. Then, structural characteristics of the people in an 800-meter radius were iterated using GIS. In addition, the Physical Activity Questionnaire was used to measure purposeful and recreational walking (active transportation). Similarly, Koohsari et al. (2015) suggested two-part criteria for neighborhood walking in a yes or no format to respond to items "any kind of purposeful walking" and "recreational walking". The neighborhood at a 10–15-minute distance from peoples' places of residence was defined. Furthermore, to measure body mass index, people's weight and height were also registered. Multivariate logistic regression was also used to investigate the discordance between objective and perceived walkability and recreational and transport walking in the neighborhood with body mass index. Socio-economic variables such as age, gender, education, marriage status, number of cars, employment, and income level were provided as mediation variables. Logistic regression analysis is concerned with the ratio between the probability of happening of a phenomenon to non-probability of happening of a phenomenon; thus, independent variables must be converted to pseudo-interval variables. To this aim, tertials were used. In other words, values of criteria of connectivity and mixed-use were exponentially regulated, and 33% lower and 33% higher were considered as lower and higher limits. Thus, perceived and objective scores were standardized and made equivalent to be made comparable. Then, the first tertial scores would constitute the higher perceived and objective groups, while the third tertial scores constitute the lower objective and perceived groups.

$$X_i = \frac{x_i - \min}{\max - \min}$$

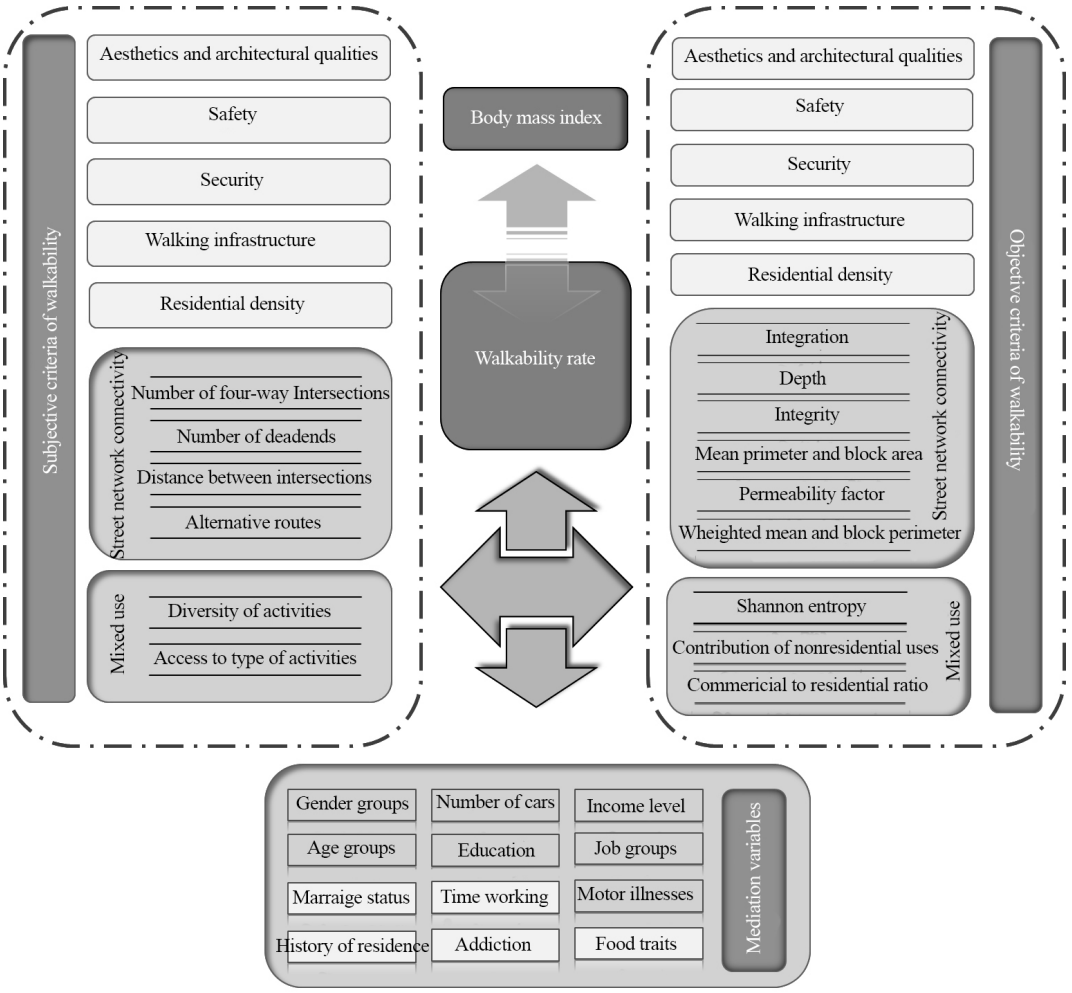

Fig. 2. Conceptual Framework of Research

4. RESULTS ANALYSIS

Findings of four parts were analyzed in a way to achieve the main research goal, which investigates the discordance between perceived and objective criteria of walkability and their link with walking and body mass index.

4.1. Comparison of Objective Walkability in Three Babol's Neighborhoods

A comparison of objective scales of case studies shows that the historical texture has lower permeability of organic network, many dead ends, and fewer but larger blocks with less street connectivity (84.9). Also, the more people move towards the internal texture of the neighborhood, the fewer options they will have to walk. Furthermore, it is not possible to have direct access to main spaces, and thus one should go through intermediating spaces to reach there. Therefore, compared to two other neighborhoods, this texture has lower connectivity but greater depth. In contrast, Farhangshahr has a regular checkered texture and provides the residents with more options for access to various areas. However, the Gol neighborhood has smaller blocks and more connectivity. Since the axes with higher integration values are the most accessible routes for entering into the area, it is more likely for people to use these routes than others. The level of historical texture is lower compared to two other neighborhoods. From an integration perspective, some parts of surrounding walls that make up the main direction of the urban bazaar are very much different from the internal sections, which have caused parts of the neighborhoods to be isolated. This way, the Gol neighborhood texture enjoys a more desirable situation, but the Farhangshahr neighborhood has better integration and is far from spatial isolation. Speaking of the mixed-use measurement in the three neighborhoods, the entropy index shows that the historical texture has a higher diversity rate (0.73) than the other two areas. The major reason for this is the way these neighborhoods are connected with the bazaar, social and cultural places such as mosques, monasteries, seminaries as well as residential areas. In contrast, the Farhangshahr neighborhood, which is designed as a relatively single-functional residential area, has an entropy index of 0.43 which denotes the least use than the other two neighborhoods.

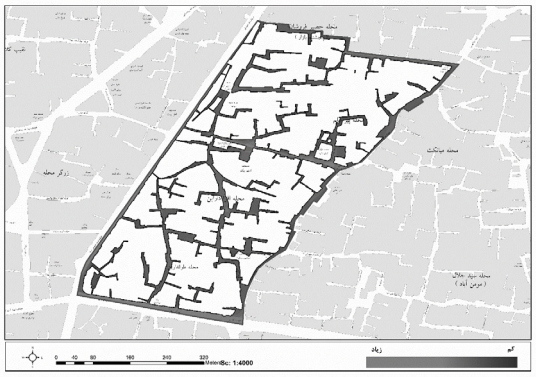

Fig. 3. Old Texture Connectivity

Fig. 4. Gol Neighborhood Connectivity

Fig. 5. Farhangshahr Connectivity

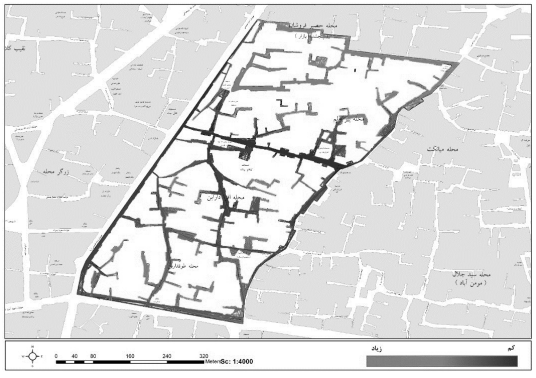

Fig. 6. Old Texture Depth

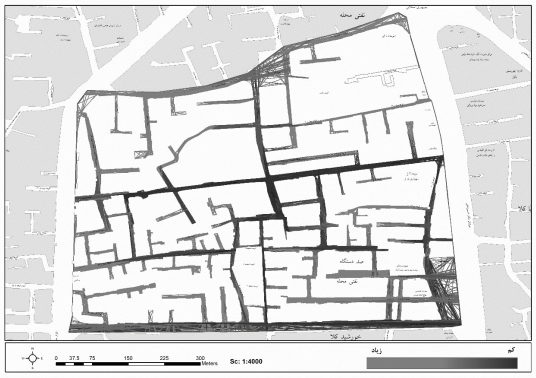

Fig. 7. Gol Neighborhood Depth

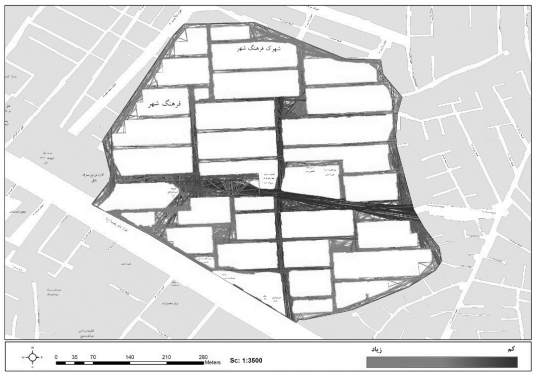

Fig. 8. Farhangshahr Depth

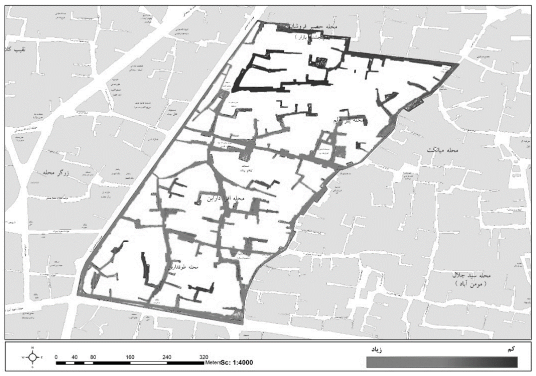

Fig. 9. Integration of Old Texture

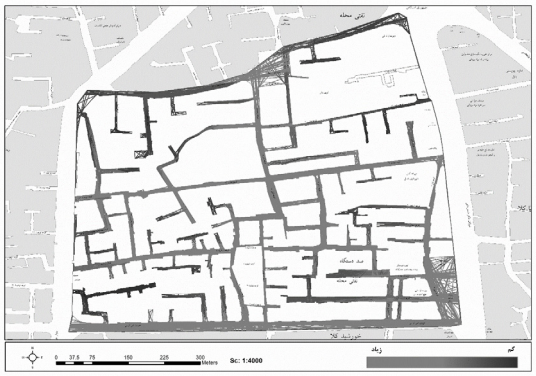

Fig. 10. Integration of Gol

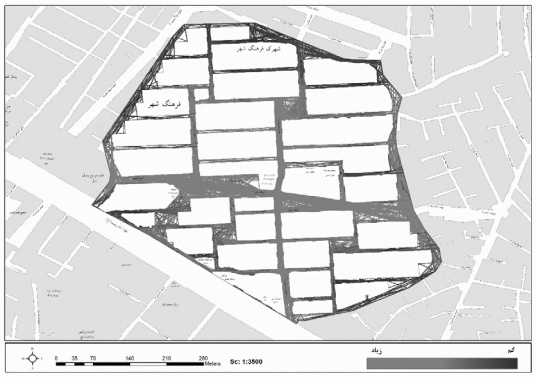

Fig. 11. Integration of Farhangshahr

Table 1. Comparison of Objective Indicators of the Communication Network in Three Neighborhoods

Component	Index	Gol	Farhangshahr	Old Texture
Connectivity	Connectivity	175.83	168.37	84.9
Depth	Depth	44258.21	10958.34	48096.29
Integration	Integration	2.64	4.16	1.59

Component	Index	Gol	Farhangshahr	Old Texture
Permeability	Total neighborhood area	343935.3	203010	199287
	Communication network area	84487.9	51549.4	39910.7
	Number of blocks	35	41	20
	Mean block area	7412	3688	7969
	Mean block perimeter	541	260	638
	Permeability	0.16	0.17	0.13
	Weighted mean of the block perimeter	502	255	612

Table 2. Mixed Land Use in the Three Neighborhoods of Babol

Indices	Gol	Farhangshahr	Old Texture
Shannon entropy	0.53	0.43	0.73
Non-residential number	0.18	0.18	0.41
Commercial to residential ratio	0.08	0.04	0.25
Commercial to non-residential ratio	0.83	0.29	1.25

The old texture has a greater number of commercial units as compared to Gol and Farahangshar neighborhoods due to the proximity of the edges of the neighborhood with the bazaar and the presence of a small part of the old texture bazaar inside the neighborhood. Estimating the total ratio of the services sector to the residential sector, the old texture is in a better situation due to the multiplicity of the commercial units. However, it suffers from a shortage of green spaces, which can reduce the tendency to walk and do optional activities. The higher number of accessible walking retailers convert them into places for public gatherings and social interactions. In this case, retailers are more than the other two neighborhoods (1.58), which can affect the modification of peoples' tendency to walk, taking into account the shortage of permeability and inappropriate connectivity. In this connection, the Farhangshahr neighborhood rate of retailers (0.29) suggests a shortage of these small users.

4.2. Comparison of perceived walkability in three neighborhoods of Babol

Most subjects were aged 18-60 (34.1%). In addition, around 60 and 8.5% of the respondents held bachelor's and master's degrees, respectively. The car ownership rate showed one car for each people and his/her family. However, the difference between the Gol Neighborhood (1.3) and the old texture (0.9) indicates the income difference and different lifestyles between the two. This difference seems to some extent to explain the difference of the number of the respondents with weight gains and those who used to walk for over 30 minutes in the two regions.

Table 3. Contribution of Body Mass Index and Subjects' Self-Reported Walking Rate

Components		Old Texture	Farhangshahr	Gol	Total
Body Mass Index (BMI)	Less than 16.5	0	3.9	0	1.3
	16.5-18.5	13.2	7.8	0	7
	18.5-25	62.5	48.1	12	50
	25-30	8.5	29.6	64	29.4
	30+	15.5	11.1	6.5	12.2
Walking Rate	Inactive	0	0	3.9	1.3
	5-15 min.	24.2	7	29.6	20.3
	16-30 min.	24.2	33.5	33.5	30.4
	31-60 min.	48.4	5.55	30.4	44.7
	Over 60 min.	3.1	3.9	2.3	3.1

As the questionnaire suggested, the communication network in the historical texture has larger intersections, fewer shortcuts, no spaces for walking (as around 64%, 73%, 76%, and 89% of the subjects disagreed and relatively disagreed), and various dead ends (as around 79% of the subjects agreed or relatively agreed). These values are largely compatible with objective characteristics of connectivity and low permeability of the historical texture. As well, people perceive walkability differently due to their place of residence and personal or socio-economic characteristics, with around 32% of them saying that the distance between the intersections is relatively short in the same texture, and around 17 and 18% saying that there were four-way intersections and various shortcuts in the texture. The extent of walking or trips with personal cars can also affect the peoples' perceptions in the neighborhood. In contrast, the subjects stated that Farhangshahr was more walkable than other neighbors. Over 60% of the people considered the neighborhood to have a relatively large number of intersections with short distances, fewer dead ends, and relatively large shortcuts. As well, they were found to provide a more coherent perception of the neighborhood than the residents of the old texture, which may be due to the regular and checkered texture of the neighborhood. The peoples' perception of the neighborhood was almost the same as the results from the objective analyses. The Gol neighborhood texture and its annexation with the adjacent areas produced some inconsistent answers on the subjects' part. However, the neighborhood texture was thought to be conducive for walking from the view of the access network. Also, three of the subjects considered the opening of the dad ends and their annexation with the adjacent neighborhoods to be a new opportunity for walking into destinations.

Table 4. Participants' Answers to Each of the Connectivity Items in the Three Neighborhoods of Babol

	Items	Compete Disagree	Somewhat Disagree	Somewhat Agree	Completely Agree
Historicla texture	Distance between the intersections is short	40.6	23.4	32.8	40.6
	Too many four-way intersections	50.7	22.6	17.1	8.5
	Shortcuts and alternative routes	46	30.4	18.7	3.9
	Too many dead ends	7.8	13.2	25.7	53.1
	Walking-conducive spaces	61.7	28.1	5.4	4.6
Farhangshahr	Distance between the intersections is short	4.6	7.8	19.5	67.9
	Too many four-way intersections	7	8.5	21	63.2
	Shortcuts and alternative routes	0	5.4	28.1	66.4
	Too many dead ends	64	27.3	6.2	2.3
	Walking-conducive spaces	8.5	7.8	48.4	35.1
Gol	Distance between the intersections is short	7.8	21	48.1	23.4
	Too many four-way intersections	7	17.9	40.6	34.3
	Shortcuts and alternative routes	3.1	21	53.9	21.8
	Too many dead ends	6.2	28.1	36.7	28.9
	Walking-conducive spaces	53.1	26.5	16.4	3.9

From a perception point of view, however, Farhangshahr, compared to the other two neighborhoods, is in a better position in terms of diversity of access to daily needs. All the subjects enumerated 4 and 5 destinations out of the 11 local destinations with distances of less than 11, 20, 21, to 30 minutes. This was far less for the subjects in the Gol and historical texture neighborhoods. However, the level of accessibilities seems to be partially dependent on the residence location and scattering of the uses in the neighborhood. Facilities are mainly concentrated at a point, while facilities in the Gol and old texture are dispersedly located, mainly far from the main streets. One would say that simple access to a diversity of facilities concentrated at a point could not necessarily increase peoples' perceptions of the activity diversity or mixed uses. This is specified in Table 6, which gives results on "there are many places around the distance,", "with 82 and

80% of the residents in the old texture and Gol neighborhoods relatively agreeing with it, though this percentage was 42% for the people located in Farhangshahr. Furthermore, access to public transportation is a major point that can increase walking time along farther working routes. It appears that residents in the Farhangshahr neighborhood have lower access to public transportation, with 87 and 60% of the Gol and old texture neighborhoods defining walking access to public transportation at a 10-minute distance, which this rate was 37% for the people in the Farhangshahr neighborhood.

Table 5. Peoples' Perception of Access to Various Facilities in the Three Neighborhoods of Babel (Minutes)

	Facilities	1-5	6-10	11-20	21-30	Over 30
Old Texture	Greengrocery	30.4	27.3	27.3	11.7	3.1
	Super market	50.7	24.2	12.5	6.2	6.2
	Laundry	17.8	42.1	39.8	0	0
	Primary school	42.1	51.5	6.2	0	0
	High school	3.1	3.1	47.6	35.9	10.9
	Restaurant or Café	0	0	29.6	51.5	18.7
	Park and green spaces	6.2	17.9	29.6	27.3	18.7
	Gym/body building	3.9	8.5	11.7	84.4	27.3
	Clinic and pharmacy	14.8	24.2	36.7	15.6	8.5
	Public transportation	11.7	48.4	36.7	3.1	0
Farhangshahr	Greengrocery	46	29.6	21	3.1	0
	Super market	74.2	21.8	3.9	0	0
	Laundry	46.7	33.5	29.6	0	0
	Primary school	29.6	51.5	18.7	0	0
	High school	18.7	14.8	62.5	3.9	0
	Restaurant or Café	7.8	10.9	29.6	14.8	36.7
	Park and green spaces	40.6	26.5	25.7	7	0
	Gym/body building	3.7	34.3	40.6	21.8	0
	Clinic and pharmacy	10.9	25.7	59.3	3.9	0
	Public transportation	10.9	25.7	59.3	3.9	0
Gol	Greengrocery	39.8	36.7	23.4	0	0
	Super market	79.6	20.4	0	0	0
	Laundry	13.2	46	36.7	3.9	0
	Primary school	13.2	67.1	19.5	0	0
	High school	10.1	20.3	63.2	6.2	0
	Restaurant or Café	9.3	10.1	17.1	36.7	26.5
	Park and green spaces	23.4	19.5	26.5	23.4	7
	Gym/body building	10.9	23.4	53.1	9.3	3.1
	Clinic and pharmacy	6.2	22.6	53.1	17.9	0
	Public transportation	50	36.7	13.2	0	0

People's subjective perception shows that the Farhangshahr neighborhood enjoys more accessibility diversity than the Gol neighborhood, but it has lower use diversity. Only 3% of the people considered the available routes to be inappropriate, as no signs of attractive factors were noted along the walking route. In addition, although open-ended items regarded the presence of wide sidewalks to be an incentive for access to facilities, it appears that straight and wide streets largely provide the space for the undisrupted presence

of the drivers. Restricted access to public transportation in the Farhangshahr was also noted as a motivation for the use of personal cars. Farhangshahr and old texture neighborhoods provide more conductive access to public transportation for longer distances compared to the internal texture of the Gol neighborhood.

Table 6. Participants' Answers to Each of the Items of the Diversity of Uses in the Three Neighborhoods of Babol

	Items	Compete Disagree	Somewhat Disagree	Somewhat Agree	Completely Agree
Old Texture	It is possible to purchase from local shops	20.3	12.5	45.3	39.8
	Th shops are located at walkable distances	3.9	10.9	60.9	25.7
	There are many places on this distance	6.2	11.7	53.9	28.1
	Pedestrian's easy access to public transportation	17.1	19.5	35.9	27.3
	Improper routes / Improper drainage	4.6	10.1	37.3	47.6
Farhangshahr	It is possible to purchase from local shops	4.6	10.9	35.1	49.2
	Th shops are located at walkable distances	7	14.8	52.3	25.7
	There are many places on this distance	32	25.7	34.3	7.8
	Pedestrian's easy access to public transportation	16.4	52.3	17.9	13.2
	Improper routes / Improper drainage	33.5	43.7	19.5	3.1
Gol	It is possible to purchase from local shops	0.7	5.4	36.7	57
	Th shops are located at walkable distances	0	6.2	35.1	58.5
	There are many places on this distance	11.7	8.5	46	33.5
	Pedestrian's easy access to public transportation	14	16.4	39.8	29.6
	Improper routes / Improper drainage	30.4	41.4	14.8	13.2

4.3. Concordance of Perceived and Objective Walkability

Generally speaking, discordance between objective and perceived walkability was clearly noted in all three neighborhoods. Discordance of connectivity criterion was found to be 54, 31, and 66% in the old texture, Farhangshahr, and Gol neighborhoods, respectively. Discordance in the old texture ensued from people's positive and greater subjective perception of the objective connectivity. On the contrary, discordance in the Gol and Farhangshar neighborhoods reveals peoples' negative subjective perception of the real connectivity. Because environmental diversity can affect the human's perception of the time spent, it appears that perception could play a more effective role in the index of connectivity, despite local and use diversity at walking distances in the old texture; this is because the existing diversity distracts the human mind from focusing on objectivity and highlights the role of perceptions. This is less conspicuous in the Gol and Farhangshahr neighborhoods because of lower diversity. Also, concerning mixed-use, the participants considered discordance between the objective and perceived environment in the historical texture Farhangshahr and Gol to be 44, 48, and 48%, respectively. This discordance was based on the existing objectivity among the residents of the historical texture and Gol neighborhoods and was based on the perceived dimension among the residents of the Farhangshar neighborhood. This may be due to the spatial distribution of use in the two neighborhoods of historical texture and Gol, which meets access for all the residents in all points. In Farhangshar, the main uses are mainly located towards the center, and the reason why the residents concentrate over the perceived dimension may, to a large extent, be affected by the concentrated access to a large part of the uses in the central part of the neighborhood. Generally, a comparison of two perceived and objective dimensions in three neighborhoods of Babol concluded that people perceived close distances to be excessively near and far distances to be unduly far. Put it more accurately, 31% of the participants perceived distance from local facilities like supermarkets and fruit retailers to be farther than they were, while 29% considered the facilities such as post offices to be closer than they were.

Table 7. Concordance of Objective and Perceived Walkability Indices in the Three Neighborhoods

	Perceived and Objective Criteria	Street Connectivity	Mixed Use
Historical Texture	Higher objective and higher perceived	10.1	44.5
	Higher objective and lower perceived	21	30.4
	Lower objective and higher perceived	32	14
	Lower objective and lower perceived	44.1	8.5
Farhangshahr	Higher objective and higher perceived	64.8	24.2
	Higher objective and lower perceived	24.3	14.8
	Lower objective and higher perceived	7	33.5
	Lower objective and lower perceived	3.9	25.7
Gol	Higher objective and higher perceived	21.8	42.9
	Higher objective and lower perceived	42.1	38.2
	Lower objective and higher perceived	24.1	10.1
	Lower objective and lower perceived	13.2	8.5
Total	Higher objective and higher perceived	30.9	37.2
	Higher objective and lower perceived	30.7	27.8
	Lower objective and higher perceived	17.1	19.2
	Lower objective and lower perceived	21.6	14.3

4.4. Measuring the Relationship between Objective and Perceived Walkability, Physical Activity, and BMI

In the end, the multi-level logistic regression was used to investigate the relationship between objective and perceived indices of the environment and self-reported walking as well as BMI. The main research hypotheses are as follow:

1. People's positive and subjective perceptions (over 33%) can increase the probability of recreational and purposeful walking in the neighborhoods where street network connectivity and mixed uses do not support walking (less than 33%), compared to the people whose subjective perceptions concord with the objective criteria.
2. People's negative and subjective perceptions (less than 33%) can decrease the probability of recreational and purposeful walking in the neighborhoods where street network connectivity and mixed uses are evaluated to be walkable from an objective point of view (less than 33%), compared to the people whose subjective perceptions concord with the objective criteria.
3. Discordance between perceived and perceived criteria affects the probability of purposeful walking over recreational walking.

The findings revealed that the probability of purposeful walking in people who live in an objective environment with low connectivity but produce positive perceptions out of it is significantly higher than those with lower subjective perceptions (42%). To contrast, the probability of purposeful and recreation walking of the people whose subjective perceptions out of the street connectivity is lower than that in the objective environment is 31 and 27% lower, compared to those who produced a consistent image of this variable in an objective environment. Although these probabilities were not significant in relation to the body mass index, they showed a reverse effect. Furthermore, the people who have a lower perception of the environment with higher use were less likely (37 and 46%, respectively) to take purposeful and recreational walking compared to those who had a subjective perception similar to the objective features. The analyses also showed that when people's perception of the neighborhood unit with lower objective mixed-use is increased, one would note a 28% increase in the probability of recreational walking. That said, no significant effect was noted between the BMI and discordance between perceived and objective criteria of mixed-use.

Table 8. Relationship between Objective and Perceived Components of Connectivity and Mixed-Use with Walking and Body Mass Index

	Components	Purposeful Walking	Recreational Walking	BMI
Connectivity	Higher objective and higher perceived	1.00	1.00	1.00
	Higher objective and lower perceived	0.69** (0.59- 1.23)	0.77* (0.1- 57.03)	1.18 (0.87- 1.49)
	Lower objective and higher perceived	1.42* (0.94- 1.48)	0.95 (0.67- 1.48)	0.91 (0.72- 1.12)
	Lower objective and lower perceived	1.00	1.00	1.00
Mixed-use	Higher objective and higher perceived	1.00	1.00	1.00
	Higher objective and lower perceived	0.63* (0.48- 0.94)	0.54** (0.0- 35.77)	1.17 (0.69- 1.65)
	Lower objective and higher perceived	1.11 (0.92- 1.68)	1.28* (0.92- 1.68)	0.87 (1.1- 04.34)
	Lower objective and lower perceived	1.00	1.00	1.00

CI= Confidence Interval[2]; OR[3]: Odds Ratio; ρ<0.05*; ρ<0.01**

5. DISCUSSION AND CONCLUSION

Discordance between the objective and perceived environments can be a cause of the low rate of active behaviors among the residents who live in walkable neighborhoods. Therefore, a review of this discordance can help identify the potential interventions to strengthen the walking behavior or the physical activities either by changing the perception of the environment or by changing the neighborhood texture features. Thus, the present article sought to investigate the discordance between the objective and perceived environment and its impacts on the purposeful and recreational walking rate and BMI in the city of Babol. Peoples' subjective perception of the connectivity index is largely associated with objective measures of the environment. However, people seem to perceive walkability differently due to their residence in the texture or their socio-economic situation. The findings suggested that there is a moderate concordance between perceptive and objective walkability of the environment, with half of the people producing a different and non-consistent perception with connectivity and real mixed-use in their own neighborhood. For example, most participants made wrong speculations about the time distance and access to destinations. This finding was largely consistent with McCormack et al. (2008), who revealed this tendency among people. That said, this discordance between objective and perceived criteria can arise from a methodological challenge. Like other studies, such as the one by Arvidsson et al. (2012), this study used a fixed radius as an objective range of neighborhood units for all the residents. This also causes yet another challenge for the comparison of the perceived and objective environment of the neighborhood unit because the people who live in adjacent areas can greatly differ over how to define the spatial dimension of neighborhood units. In addition, discordance may be caused by the contradictions between the defined neighborhood units and those defined by the researchers.

Also, the results of this study are consistent with those of Gebel et al. (2009) and Koohsari et al. (2015), who maintained that subjective perceptions of environmental characteristics were more associated with physical activity than objective criteria. Analyses indicated that a positive subjective perception in a neighborhood with lower objective connectivity could affect the probability of purposeful walking (42%). In contrast, negative subjective perceptions in an environment with higher connectivity can reduce the probability of people's purposeful and recreational walking (31% and 23%, respectively). These findings also apply to mixed-use. In other words, the user's positive subjective perception of mixed-use in neighborhoods with a relatively single-functional performance can increase the probability of recreational walking by 28% compared to those who lack this subjective perception. In contrast, when residents have a low subjective perception of a relatively mixed environment, the probability of recreational and purposeful walking is decreased by about 46 and 37%, respectively. However, the odds ratio, although it shows the positive effect of the perceived dimension on body mass index, both in terms of connectivity and mixed-use, effects are not significant, which may be due to the dependence of body mass index on other

factors such as environment and eating habits.
The findings also concluded that policies to strengthen physical activity through designing and changing the environment would better stress the components which not only strengthen the walkable structural environment but positively affect the users' subjective perception. This process, which is usually aimed at reducing the level of manipulation, can be more useful invaluable historical contexts.
Lack of local-based medical information was s a constraint of the present study. Also, the present study focuses on only two main dimensions of walkability. In sum, the conduct of studies that can cover a more comprehensive range of walkable components and indicators as well as health data is proposed.

END NOTE

1. One of the effective research on the research method of this article is the article "Mismatch between perceived and objectively measured land use mix and street connectivity: associations with neighborhood walking" which was done in 2015 by Koohsari et al.
2. The "Confidence Interval" measures the certainty or uncertainty of the sampling method and the population parameter in a numerical range or distance.
3. Odds ratio denotes the probability of a phenomenon occurring over the probability of its non-occurrence. It is the ratio of the probability of occurrence of an outcome assuming membership in the first group to the probability of its occurrence assuming membership in the second group.

REFERENCES

- Azadi-Ghatar, S., Meshkini, A., Roknuddin Eftekhari, A.R., Mustafawi, E. & Ahadnejad Roshti, M. (2017). Explaining the relationship between the walkability of urban areas and the spatial distribution of deaths from breast and colorectal cancers in Tehran, *Spatial Planning and Planning*, 21(3), 55-94. https://www.sid.ir/fa/journal/ViewPaper.aspx?id=463099
- Bahraini, S. H., & Khosravi, H. (2010). Structural-spatial criteria are affecting walking rate, health, and physical fitness. *Honar-Ha-Ye-Ziba*, 42(2), 16-5. https://www.sid.ir/fa/journal/ViewPaper.aspx?ID=257615
- Rezazadeh, R., Zebardast, E., & Latifi-Uskouei, L. (2011). Subjective assessment of walkability and its influential components in neighborhoods, case study: Chizar neighborhood. *Quarterly Journal of Urban Management*, 9 (28), 297-313. https://www.sid.ir/fa/journal/ViewPaper.aspx?id=174981
- Safari Rad, A., & Shams, M. (2017). Comparative study of walkability criteria in urban neighborhoods (Case study: New and old neighborhoods of Rasht). *Quarterly Journal of Environmental Planning*, 10(4), 183-204. https://www.sid.ir/fa/journal/ViewPaper.aspx?id=312924
- Kalantar, A., & Shabian, P. (2018). Assessing the walkability of urban neighborhoods using the Walk Score Method, case study: Laleh Park and Ivanka neighborhoods. *Armanshahr*, 11(2), 211-223. https://www.sid.ir/fa/journal/ViewPaper.aspx?ID=489378
- Lotfi, S., & Shakibaei, A. (2013). Investigation and test of walkability index and its relationship with the built urban environment, case study: Qorveh city, *Armanshahr*. 6(2), 383-392. https://www.sid.ir/fa/journal/ViewPaper.aspx?ID=241843
- Arvidsson, D., Kawakami, N., Ohlsson, H., & Sundquist, K. (2012). Physical activity and concordance between objective and perceived walkability. *Med Sci Sports Exerc*, 44(2), 280-287. doi: 10.1249/MSS.0b013e31822a9289
- Baldock, K. L., Paquet, C., Howard, N. J., Coffee, N. T., Taylor, A. W., & Daniel, M. (2019). Correlates of discordance between perceived and objective distances to local fruit and vegetable retailers. *International journal of environmental research and public health*, 16(7), 1262. https://doi.org/10.3390/ijerph16071262
- Consoli, A., Nettel-Aguirre, A., Spence, J. C., McHugh, T.-L., Mummery, K., & McCormack, G. R. (2020). Associations between objectively-measured and self-reported neighborhood walkability on adherence and steps during an internet-delivered pedometer intervention. *Plos one*, 15(12), e0242999. doi: 10.1371/journal.pone.0242999
- Desgeorges, M. M., Nazare, J.-A., Enaux, C., Oppert, J.-M., Menai, M., Charreire, H., . . . Roda, C. (2021). Perceptions of the environment moderate the effects of objectively-measured built environment attributes on active transport. An ACTI-Cités study. *Journal of Transport & Health*, 20, 100972. doi: https://doi.org/10.1016/j.jth.2020.100972
- Gebel, K., Bauman, A., & Owen, N. (2009). Correlates of non-concordance between perceived and objective measures of walkability. *Annals of behavioral medicine*, 37(2), 228-238. doi: https://doi.org/10.1007/s12160-009-9098-3
- Gebel, K., Bauman, A. E., Sugiyama, T., & Owen, N. (2011). A mismatch between perceived and objectively assessed neighborhood walkability attributes: prospective relationships with walking and weight gain. *Health & place*, 17(2), 519-524. doi: https://doi.org/10.1016/j.healthplace.2010.12.008
- Hajna, S., Dasgupta, K., Halparin, M., & Ross, N. A. (2013). Neighborhood walkability: field validation of geographic information system measures. *American Journal of Preventive Medicine*, 44(6), e55-e59. doi: https://doi.org/10.1016/j.amepre.2013.01.033
- Herbolsheimer, F., Mahmood, A., Ungar, N., Michael, Y. L., Oswald, F., & Chaudhury, H. (2020). Perceptions of the neighborhood-built environment for walking behavior in older adults living in close proximity. *Journal of applied gerontology*. doi: https://doi.org/10.1177/0733464820979258
- Hillier, B. (2009). The city as a socio-technical system a spatial reformulation.
- Jack, E., & McCormack, G. R. (2014). The associations between objectively-determined and self-reported urban form characteristics and neighborhood-based walking in adults. *International journal of behavioral nutrition and physical activity*, 11(1), 1-11. doi: https://doi.org/10.1186/1479-5868-11-71
- Kent, J. L., Ma, L., & Mulley, C. (2017). The objective and perceived built environment: What matters for happiness?. *Cities & Health*, 1(1), 59-71. doi: https://doi.org/10.1080/23748834.2017.1371456
- Koohsari, M. J., Badland, H., Sugiyama, T., Mavoa, S., Christian, H., & Giles-Corti, B. (2015). A mismatch between perceived and objectively measured land use mix and street connectivity: associations with neighborhood walking. *Journal of Urban Health*, 92(2), 242-252. doi: 10.1007/s11524-014-9928-x
- Koohsari, M. J., Oka, K., Nakaya, T., Shibata, A., Ishii, K., Yasunaga, A., & McCormack, G. R. (2020). Environmental attributes and sedentary behaviors among Canadian adults. *Environmental Research Communications*, 2(5), 051002. doi: 10.1088/2515-7620/ab8b2a
- Koohsari, M. J., Sugiyama, T., Hanibuchi, T., Shibata, A., Ishii, K., Liao, Y., & Oka, K. (2018). Validity of Walk

Score® as a measure of neighborhood walkability in Japan. Preventive medicine reports, 9, 114-117. doi: https://doi.org/10.1016/j.pmedr.2018.01.001

- Lee, E., & Dean, J. (2018). Perceptions of walkability and determinants of walking behavior among urban seniors in Toronto, Canada. *Journal of Transport & Health*, 9, 309-320. doi: https://doi.org/10.1016/j.jth.2018.03.004
- Loh, V. H., Veitch, J., Salmon, J., Cerin, E., Mavoa, S., Villanueva, K., & Timperio, A. (2020). Environmental mismatch: do associations between the built environment and physical activity among youth depend on concordance with perceptions?. *International journal of environmental research and public health*, 17(4), 1309. doi: https://doi.org/10.3390/ijerph17041309
- Ma, L., & Dill, J. (2017). Do people's perceptions of neighborhood bikeability match" reality"?. *Journal of Transport and Land Use*, 10(1), 291-308. doi: http://dx.doi.org/10.5198/jtlu.2015.796
- Manaugh, K., & Kreider, T. (2013). What is mixed-use? Presenting an interaction method for measuring land use mix. *Journal of transport and land use*, 6(1), 63-72. doi: https://doi.org/10.5198/jtlu.v6i1.291
- McCormack, G. R., Cerin, E., Leslie, E., Du Toit, L., & Owen, N. (2008). Objective versus perceived walking distances to destinations: correspondence and predictive validity. *Environment and Behavior*, 40(3), 401-425. doi: https://doi.org/10.1177/0013916507300560
- Orstad, S. L., McDonough, M. H., Klenosky, D. B., Mattson, M., & Troped, P. J. (2017). The observed and perceived neighborhood environment and physical activity among urban-dwelling adults: The moderating role of depressive symptoms. *Social science & medicine*, 190, 57-66. doi: https://doi.org/10.1016/j.socscimed.2017.07.026
- Pafka, E., & Dovey, K. (2017). Permeability and interface catchment: measuring and mapping walkable access. Journal of Urbanism: *International Research on Placemaking and Urban Sustainability*, 10(2), 150-162. doi: 10.1080/17549175.2016.1220413
- Peters, M., Muellmann, S., Christianson, L., Stalling, I., Bammann, K., Drell, C., & Forberger, S. (2020). Measuring the association of objective and perceived neighborhood environment with physical activity in older adults: Challenges and implications from a systematic review. *International journal of health geographics*, 19(1), 1-20. doi: 10.1186/s12942-020-00243-z
- Saelens, B. E., Sallis, J. F., Black, J. B., & Chen, D. (2003). Neighborhood-based differences in physical activity: an environment scale evaluation. *American journal of public health*, 93(9), 1552-1558. doi: 10.2105/ajph.93.9.1552
- Shatu, F., Yigitcanlar, T., & Bunker, J. (2019). Objective vs. subjective measures of street environments in pedestrian route choice behavior: Discrepancy and correlates of non-concordance. Transportation Research Part A: Policy and Practice, 126, 1-23. doi: https://doi.org/10.1016/j.tra.2019.05.011
- Stangl, P. (2019). Overcoming flaws in permeability measures: modified route directness. *Journal of Urbanism: International Research on Placemaking and Urban Sustainability*, 12(1), 1-14. doi: https://doi.org/10.1080/17549175.2017.1381143

HOW TO CITE THIS ARTICLE

Khatami, S. M., Shahabi Shahmiri, M., Akbari, Z., & Roushenas, S. (2022). Relationship between Objective and Perceived Criteria of Walkability and Walking rate with Body Mass Index; Case Study: City of Babol. *Armanshahr Architecture & Urban Development Journal*. 14(37), 157-172.

DOI: 10.22034/AAUD.2022.252643.2334
URL: http://www.armanshahrjournal.com/article_146506.html