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RESEARCH PAPER

The Influence of Safety and Comfort on Walkability in Erbil City Center

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A B S T R A C T:

The designing and planning of walkable public open spaces are gaining popularity due to the numerous advantages they bring in terms of health, ecology, economics, and social interactions. It is noted that walkable city centers have become common topics not only among academics but also among the general public, especially in the fields of environmental and ecological concerns and transportation. Because of the lack of scientific evidence and understanding of public space walkability in the city center, the relationship between public open space design characteristics and walkability in Erbil city center has not been studied yet. Therefore, this study evaluated the influence of safety and comfort on walkability as factors related to public open space design characteristics in Erbil city center. For this purpose, three case studies were selected in Erbil city center and a combination of both subjective (questionnaire survey) and objective assessments (observation and checklist) was used. According to the results of the statistical analysis, it is revealed that there were substantial discrepancies in residents' contentment levels in different areas regarding walkability conditions in terms of the parameters examined, but there were no significant differences between the outcomes of the two measuring methods (subjective and objective) that were utilized.

KEY WORDS: walkability; safety; comfort; spatial analysis; pedestrian satisfaction
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1. INTRODUCTION:

Walkability, according to Jacobs, is the essence of urban vitality and vibrancy (Jacobs, 1961). It has several descriptions and definitions. In general, it can be defined as the level toward which having a walk as a means of transportation is comfortable, accessible, and pleasurable. City centers because of their mixed-use nature and location as the central focus for localities, could be the most approachable locations to convert into walkable centers. Erbil city, the capital of the Kurdistan region, is witnessing rapid growth. Therefore, there is a need to investigate walkability in terms of public open space, especially in city centers, as they are the most vibrant places, and they work like a magnet to attract people and tourists.

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1.2.Walkability Dimensions:

According to Edwing and Handy (2009), the main dimensions of walkability in urban space can be divided into three categories: ‘physical features,’ ‘individual reactions,’ and ‘qualities of urban design’. Many other models express the dimensions of walkability, among them the model proposed by Lynch, Punter, and Montgomery. Based on this model, the main dimensions of walkability can be classified into three main dimensions, and they are ‘physical features,’ ‘social activities,’ and ‘perceptual dimensions’ (Marzbani et al., 2020). While (Abdullah, 2019) determined the main dimensions of walkability as ‘socio-demographic, accessibility, aesthetic, mixed land-use, diversity, company dimension, pedestrian facilities, safety’. The main dimensions according to various references have been summarized by the authors in **Table.1**.

1.2.1 Physical features or characteristics:

Designers have always been concerned with the physical features of a space. As a result, some aspects of the physical environment are included in some levels of the major urban walkability theory. In this regard, Carmona's module of 5

subgroups, including ecological, spatial, morphological, contextual, and visual, was used to generate the 5 physical dimensions of a location (Marzbani et al., 2020).

The aspects that are related to space consist of the spatial dimensions that impact the behavior of humans; the built environment's compacted form or sprawled form; mixed-use; open spaces; the hierarchy of roads; the pattern of settlement; neighborhoods; mobility; public and private levels of the hierarchy; space permeability; scale; vehicle user range, public transportation availability; space structure; and density and accessibility of the built-up space (Ferry, 1999; Lynch, 1980). As for morphological features, they are related to significant aspects that have a significant influence on human behavior. Architects have long attempted to comprehend and determine the physical environment's pattern: housing, crosswalks, side parking, constructing lines, density, layout, public spaces, street pattern, squares, plazas, size of the block, connectivity, edge, designs, node, landmark, network, proportions, and material of the building (Alexander, 1977; Sitte, 1889). Features that are related to context consist of any location's contextual characteristics that have a significant impact on its identification. Landscapes, sights, sceneries, religious settings, conventional design, appearances, limits, and grouping of the buildings are some of the elements that determine the degree of walkability in a given context (Tibbalds, 1992). And finally, the features related to visuals encompass the arts and provide coherence, organization, clarity, massing, colors, styles, material, proportion, pattern, detailing, balancing, corners, focal points, shapes, harmonic, landmark, scale, rhyming, skylines, mass, void, horizontal and vertical, visibility of urban infrastructure, parking spaces, and visual connection for walkers. These are the visual aspects linked to the walkability of a space (Cullen, 1961; Gibberd, 1967; Unwin, 1909).

1.2.2. "Social activities":

According to Gehl, activities can be grouped under three categories: ‘necessary,’ ‘optional,’ and ‘social.’ The majority of optional and social activities are done in the mundane settings of urbanized neighborhoods (Gehl, 1987). "Necessary activities" are activities that are more or less required, like going out to work or waiting for the bus. Infrastructure facilities, accessibility, lively frontages, criminality, accessibility for people with disabilities, mobility patterns, public realm, health services, community realm, social inclusion, community cohesion, requirements of minorities, personalization, safety, aging, gender, and race may all influence the level of required activities (Jacobs, 1961). ‘Optional Activities’ are actions taken voluntarily. This segment covers things like going on a walk to get some fresh air or just going about and experiencing life. Physical circumstances play a significant role in the development of this type of behavior. More spatial efficiencies, mobility, facilities for eating, sitting and standing areas, pedestrian areas, feeling of security at night, play areas, convenience, safety, protection, vibrancy, numbers, and range of people, cleanliness, confidentiality, and customization (Buchanan, 1988) are all factors that influence optional actions (Lang, 1994). And finally, ‘social activities’ are occurrences that rely on the existence of others in public areas, including greetings and conversations, as well as inactive connections, such as merely seeing and listening to other individuals. This category involves delivering services and amenities for entertainment, mixed land uses, green spaces, lighting, slow traffic conditions, crosswalks, public utilities, and areas of shade (Buchanan, 1988; Cooper, 1988; Lang, 1994).

1.2.3. Dimensions of Perception:

Perceiving our surroundings or our feeling of location is divided into two phases: ‘perception’ and ‘cognition’ (Kopec,2012). The phase of perception in a place pertains to the process of sensuous experience and is often connected to sounds, scent, touch, view of a sight, as well as perceptions of aesthetics, cultural backgrounds, the location's adaptability, improvement, renovation, and visual recalling of past usage (Kopec, 2012). While the mental or cognitive phase is related to other related concepts, this dimension includes five key elements of Lynch: "paths, edges, districts, nodes, and landmarks", as well as cultural pride, uniqueness, degree of enclosure, sense of belonging, diversity, human scale, identification and distinctiveness, appearance, memorial perception, understandability of the layout, and navigation (Appleyard, 1981; Rapoport, 1982). The potential of individuals to connect with their spaces in multiple perceptions is associated with the form of

the urban and physical environment's structure and characteristics that impact pedestrians (Southworth, 2005). That's why these characteristics are important in users' activities and also in the walkability of an area (Brown et al., 2007). Also, according to Edwing and Handy (2009), physical characteristics influence the quality of the walking environment both directly and indirectly. In this study, researchers are trying to focus on evaluating the influence of design characteristics of public open spaces on walkability by using two factors that affect walkability, which are safety and comfort. Finally, based on the different references, the public open space design characteristics of this study are summarized in **Table 2.**

2.0. Factors affecting walkability at the public open space level:

The association between walking and diverse environmental aspects has been explored in many studies. Several investigations placed a greater emphasis on the parameters of the physical environment and the design of roads than on user perceptions (Abdullah, 2019). There are some common factors and features observed in evaluations of public walking areas. Numerous studies suggest that certain aspects of built environments could affect people's walking in public open spaces (Jacobs, 1961). Finally, The Bicycle Federation of America (1998) identified the main factors or features of a walkable city as: cohesion, continuity, pedestrian safety, ease of access, paving and crossing, resurfacing materials that are safe and adaptable on the roadway, social aspects related to a feeling of friendliness and an aptitude for personal and group engagement (Bicycle Federation of America, 1998).To sum up, the main factors that affect walkability can be summarized as objective, subjective, and built-environment factors, as shown in **Table .3**

3.0.The study's scope

Safety and comfort factors and their impacts on walkability through public open space design characteristics in Erbil city center are evaluated. The majority of previous studies on walkability had studied these factors separately, such as (Abdullah, 2019; Southworth, 2005; Maghelal and Capp, 2011; Nakamura2020; Salam et al., 2020). This study combined these two factors to examine their effects on walkability issues in public open spaces in Erbil city center. While many previous studies investigated streets or squares separately, the current study looks at these two as a subsystem.

3.1. Safety factor

People will feel protected in settings where others are going through their daily routines (Jacobs, 1961). Roadways, elevated medians, improved bus station locations, reduced vehicle interventions, and services for impaired travelers are all examples of measures that build the roadway for pedestrians and enhance pedestrian safety (Southworth, 2005). In this study, safety indicators are lightning (Salam et al., 2020; Rani et al., 2018); traffic (Rani et al., 2018), specific self-space, overall safety, democratic place, the existence of people in public open space (Abdullah, 2019); quality of pathways, lighting, and the availability of street signs (Shamsuddin et al., 2012; Zakaria and Ujang, 2015).

3.2. Comfort factor:

Comfort is defined by Alfonzo as an individual's sense of ease, pleasure, and satisfaction (Alfonzo, 2005). According to Sarkar, it is a pleasurable condition of physical, mental, and bodily equilibrium between an individual's body and its surroundings (Sarkar, 2002). Both authors refer to the positive sensation that humans have when interacting with their surroundings. In this study, comfort indicators are related to the variety of surroundings (Radha et al., 2020), the availability of pedestrian crossings (Nakamura, 2020), signs, width, non-slippery surfaces, the height and dimensions of the sidewalks and pathways, availability of seats and the presence of shadowing elements on the sidewalks and pathways (Rani et al., 2018; Shamsuddin et al., 2012), overall cleaning (Abdullah, 2019; Maghelal and Capp, 2011; Zakaria and Ujang, 2015), and benching area and other natural elements (Cauwenberg et al., 2012; Maghelal and Capp, 2011), public toilet availability (Abdullah, 2019). Finally, the main indicators of the current study are summarized in **Table .4**

Table.1: Dimensions of walkability based on various references (Researchers)

The reference	Dimensions of walkability
(Edwing and handy,2009)	'Physical features, Individual reactions, and Qualities of urban design'
(Lynch, Punter, and Montgomery) (Marzbani et al 2020).	'Physical Features, Social Activities, and Perceptual Dimensions'
(Abdullah,2019)	'Socio Demographic, Accessibility, Aesthetic Mixed land use ,diversity, Company Dimension, Pedestrian facilities, Safety'

Table.2: Public open space (POS)design characteristics based on various references(Researchers)

The reference	(Physical or POS design characteristics that related to the factors	Walkability factors related to the POS design characteristics (details in chapter 2)
(Salam et al .,2020) (Rani et al,2018) (Cauwenberg et al.,2012), (Abdullah, 2019), (Abdullah, 2019), (Abdullah, 2019), (Zakaria and Ujang, 2015), (Salam et al .,2020) , (Zakaria and Ujang, 2015) (Shamsuddin et al. ,2012), (Shamsuddin et al. ,2012), (Zakaria and Ujang, 2015), Southworth, 2005 (Abdullah, 2019)	Lightning, traffic , Specific self-space, Overall safety, Democratic place, Quality of pathways, Surrounding land uses, sidewalk width, pathway width, lightening and signs availability, street crossing availability,)existence of people in POS	Safety
(Radha et al,2020), (Nakamura,2020), (Shamsuddin et al. ,2012) (Rani et al,2018), (Abdullah, 2019) (Maghelal and Capp,2011), (Nakamura,2020) (Rani et alm,2018)(Zakaria and Ujang, 2015) , (Cauwenberg et al.,2012)	Variety of surrounding, Availability of pedestrian crossing, The height and dimensions of the sidewalks and pathways, Overall cleaning, Presence of shadowing elements on the sidewalks and pathways, Availability of seats,benching area and other natural elements, non- slippery surfaces width, public toilet availability, signs	Comfort

Table.3: Main factors impacts walkability (Researchers)

Factors Affecting Walkability			
Built Environment /Objective Factors		**Personal /Subjective Factors**	**Environmental Factors**
Image & Identity Accessibility Maintenance Performance Or Functionality Flexibility Inclusiveness Linking with soundings Vitality and vibrancy Enclosure Amenities Clearness View Attractiveness Building Design Articulation Legibility Human Dimensions Site's Contextual Relations Integration Of Design Location Issues	Street Dimensions Area And Size Protected Space Historical Landmark Material Density Factors Less Traffic Roads Mixed Land Use Diversity Distances Lightening Connectivity Aesthetic Segment Intersection Safety Obstacles Public Transportation Pathway Pattern And Quality Orientation Zoning	Walking Distance Walking Purpose Comfort Social and Economic Factors Time Age and gender Activity Or Exercise Health Condition Habit Valuation And Attitudes Having Friends Car ownership	Climate Topography of Land

Table. 4: Indicators of the walkability of the current research (Researchers)

Walkability (Dependent indicators or variables)	
Walkability indicators of the study (Independent indicators or variables)	
Safety	Comfort
Lighting, traffic, specific self –space, the existence of people in POS, common place, quality of pathways, ,non-slippery surfaces sign and pedestrian crossing availability	The height and dimensions of sidewalks and pathways, availability of seats, presence of shadowing elements on the sidewalks and pathways, overall cleaning, benching area and other natural elements, public toilet availability

3.3 Research Questions:

1. Is there a significant difference in user satisfaction levels regarding the walkability indicators in Erbil city center?
2. Is there a significant correlation between walkability indicators in the public open spaces of Erbil's city centre?
4 Is there any correspondence between the results of objective and subjective measurements of the public open spaces?

3.4 Research Hypothesis:

H1: There is a significant difference in user satisfaction levels on the walkability indicators in public open spaces in Erbil city center.
H2: There is a significant correlation between studied walkability indicators in Erbil city center's studied public spaces.
H3: There is correspondence between measurement results gained by objective measurement and subjective measurement.

3.5. Research methodology:

Four tools of subjective and objective measurements were used, and they were (PEDS, "Pedestrian Environment Data Scan" checklist for streets(Haykal and Abdulah, 2018), POS(public open space) checklist for squares, questionnaire, and observation). The objective checklists' scoring value was ranked from 0 to 4, while observation (Abdullah, 2019) was used objectively based on the photo analysis(Radha et al., 2020) of each study area, and the Likert scale was used for the subjective questionnaire survey(Haykal and Abdulah, 2018), ranked from (1 strongly disagree to 5 strongly agree).

3.5.1.Sample selection:

This study considers that the city center is a system consisting of several subsystems, each of which is composed of a square and some streets connected to it. For this reason, three areas in Erbil city center have been selected, and each area consists of a square and the streets linked to it because the square is principally situated at the crossroads of multiple walking systems to serve as a center for those who walk through it on a routine basis. This study selected three case studies in Buffer-Zone (A) of the city center by using cluster sampling because, with most investigations, when selecting a basic representative sample of people throughout the study area would be impracticable, a cluster-sample method will be the only viable solution (Bennett et al., 1991). Thus, Nishtiman subsystem, Kotri Salam subsystem, and Governorate subsystem, were selected as case study areas **Figs. 1&2.** As for the sample size, it depends on the observation that has been made by the researcher, as shown in **Appendix. 4** . The general sampling size concept is that the size of sampling should symbolize ten percent of the size of the total population. Thus, the number of the chosen samples should be no less than 100 and no more than 1000 samples of the total population size, considering if the sample size is more than a thousand it will cause economic and time losses (Taherdoost, 2017). Therefore (292) respondents were questioned and (292) forms were distributed in total, (180) in Nishtiman (77) in Kotri Salam, and (35) in Governorate. Also, the way of calculating sample size is shown in **Appendix.5**

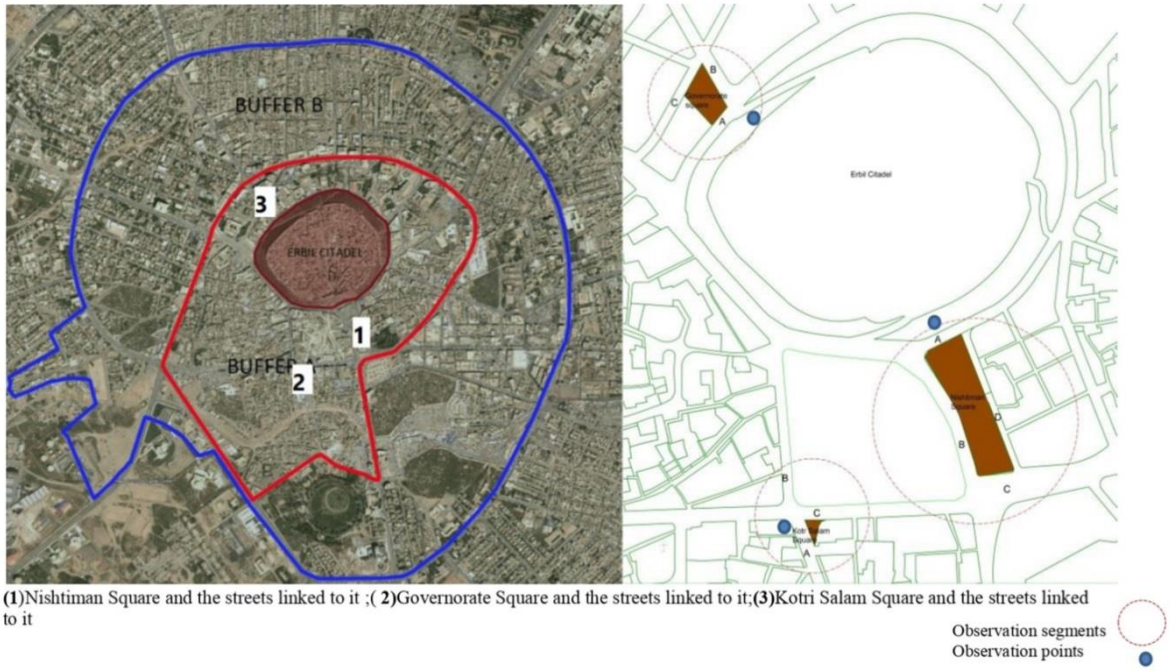


Fig.1: Location of segments in Erbil city center, (Researchers)

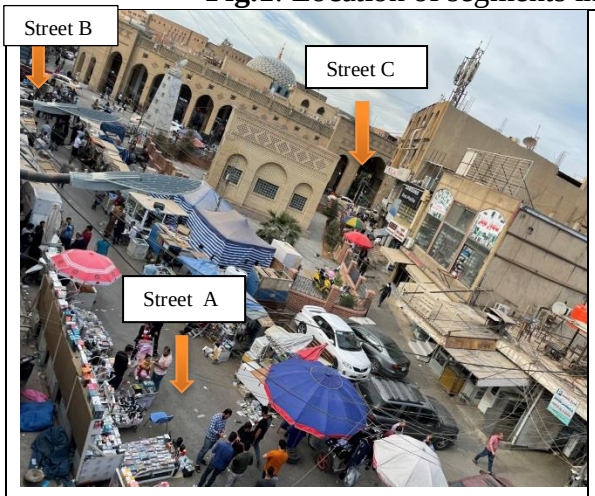
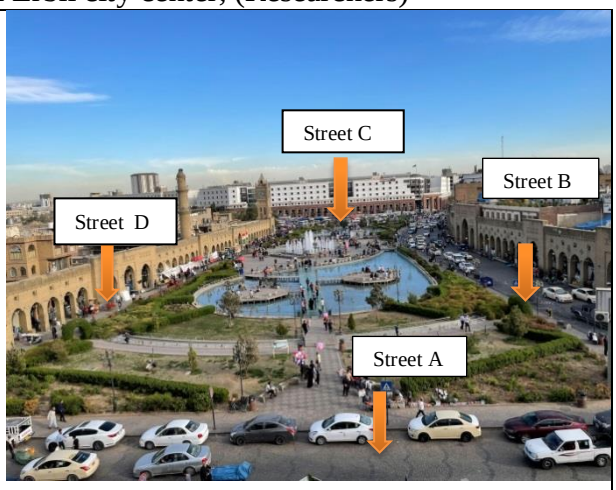


Photo #1
(Kotri Salam Square and the streets linked to it) , Source: Researchers



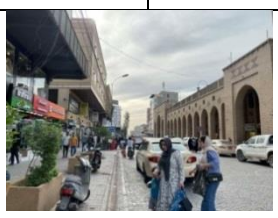
Photo#2
(Nishtiman Square and the streets linked to it) ,Source: Researchers

A

B

A

B



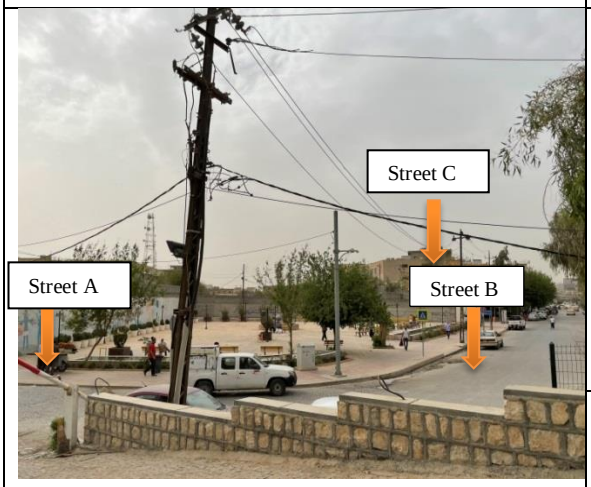
C

Photo#3,4,5 :Street A,B,C (Kotri Salam Square's linked streets , Source: Researchers

C

D

Photo#6,7,8,9:Street A,B,C (Nishtiman Square's linked streets, Source: Researchers



Photo#10
(Governorate Square and the streets linked to it) , Source: Researchers

A

B

C

Street C(closed by Governorate building for some security reasons and became a part of the building

Photo#11,12,13 Street A,B,C (Government Square's linked streets, Source :Researchers

Fig.2: Location and photos of current condition of segments in Erbil city center (Researchers)

4.0 Outcomes and results discussion:

4.1.Analyzing and discussing safety indicators in the squares through Spatial Analysis (Objective Measurement):

To evaluate the safety variable for each studied area and to determine the final scoring value that mirrored this indication, as shown in Fig. 3, the researchers calculated the average mean score for the pertinent sub-indications A1 to A3. Places with the highest-scoring average mean showed more safety characteristics and are considered to be much more walkable than the lower scoring ones, theoretically.

The outcomes reveal that among the studied areas, the highest-scoring records for safety are recorded in Nishtiman Square, this means that this area is the safest and most secure among case studies. They are controlled by guarding points and also the quality and condition of pathways, lighting aspects, traffic, and these places' separation. These values reflect the availability of overall safety features in these locations, while the lowest record value goes to Kotri Salam Square, because most safety features are lacking in this place, as a result of the crowds not being separated from vehicles, and the lack of many safety features such as lighting aspects and traffic control devices, see **Appendix. 8.**

4.1.2. Analyzing and discussing the comfort variable:

To evaluate the comfort variable for each studied area and to determine the final scoring value that mirrored this indication, as shown in Fig. 3, the researchers calculated the average mean score for the pertinent sub-indications B12 to B19. Places with the highest-scoring average means to have more comfortable characteristics and are considered to be much more walkable than the lower scoring ones that theoretically encourage walking.

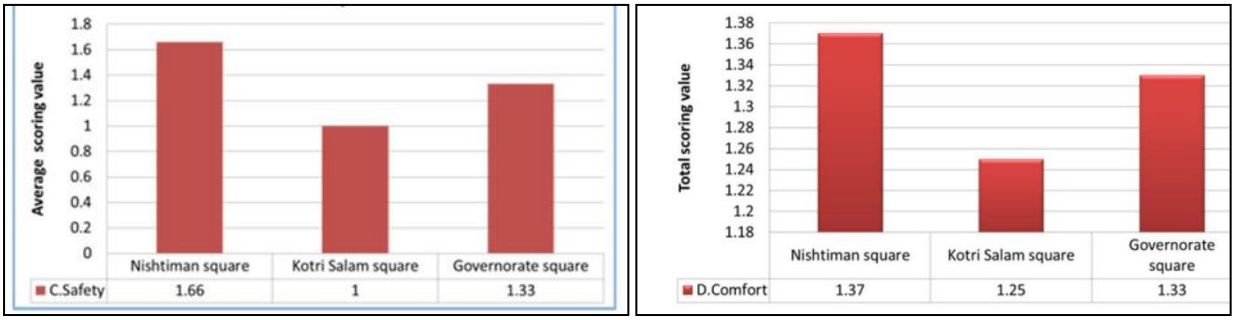


Fig.3: Comfort and safety indicators' average score value for each of the 3 studied areas

The results show that among the studied areas, the highest-scoring record for comfort is recorded in Nishtiman Square, which reflects the availability of facilities or features that make pedestrians feel comfortable in this place among case studies, by virtue of features such as fountains, sculpture, tree, variety of surroundings, availability of benches, and good pathway condition, while the lowest record value is recorded in Kotri Salam Square, as a result of the lack of the above-mentioned features in this place in addition to the lack of shade for pedestrians during their walking experience that resulted in a crowded marketplace. And the other square, which is Governorate Square, has an average score value of 1.33, which means in terms of comfortableness, it comes in second place after Nishtiman Square, see **Appendix. 8.**

4.2. Discussion of Spatial Analysis (Objective Measurement) checklist Outcomes in streets:

4.2.1 Analyzing and discussing the safety variable

To evaluate the safety variable for each studied area that mirrored this indication, as shown in Fig.4, the researchers calculated the average mean score for the pertinent sub-indications A11 to A15 (see **Appendix. 9**).

The outcomes reveal that among the studied areas, the highest-scoring records for safety are recorded in the streets linked to Kotri Salam Square, which means that this area is the safest and most secure among case studies and is more walkable theoretically. That resulted in POS design characteristics of this place, such as lighting aspects, non or slow traffic conditions, articulation, and a good degree of enclosure of these streets that affected the overall safety in these streets, while the lowest record value recorded in the streets linked to Nishtiman Square this result is related to the unavailability of buffer between the streets and the pedestrian sidewalks and pathways, as well as little façade articulation, and a lack of traffic control devices, which affects the safety feature. The streets linked to the Governorate Square have a PEDS recording value of 13, which reflected the lack of some safety features in this place, such as a buffer between pedestrians and the streets, where people have to pass between cars to get to most of the buildings; the availability of some enclosures in these streets also affected the overall safety of these streets.

4.2.2. Analyzing and discussing the comfort variable:

To evaluate the comfort variable for each studied area and to determine the final scoring value, as shown in Fig. 4, the researchers calculated the average mean score for the pertinent sub-indications A16 to A23 shown in **Appendix.9.**

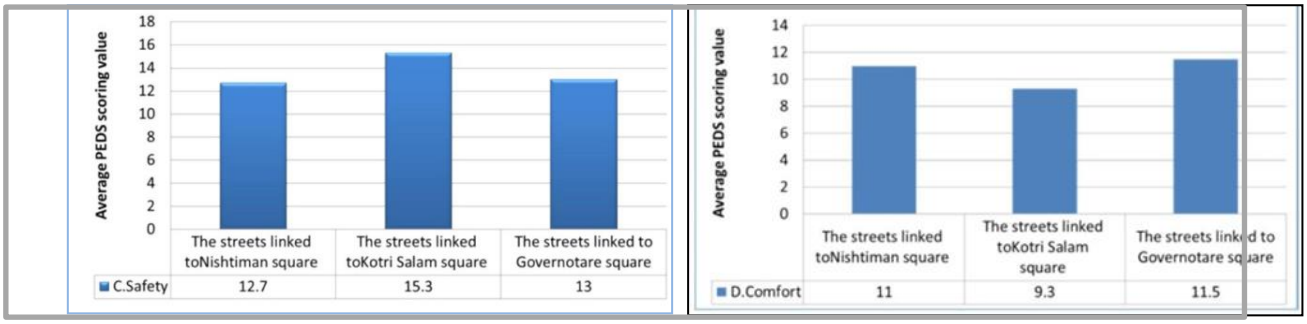


Fig.4: Comfort and safety indicators' average PEDS scoring value for the streets linked to the squares in each 3 studied areas, Source; Author

It is revealed that the highest-scoring record for comfort is going to the streets linked to Governorate Square which reflects the availability of features that make pedestrians feel comfortable in this place and encourage people to walk. The lowest record value was in the streets linked to the Kotri Salam Square as a result of the lack of the majority of comfortable features in this place, such as (fountain, sculpture, tree, and other features unavailability, unavailability; of seats bad pathway condition, lack of shadowing for pedestrians during their walking experience) which resulted in the crowdies of this place and being a market placing street. And finally, the streets linked to Nishtiman Square have an average scoring value as a result of the unavailability of some comfort features for the pedestrians and users of these streets and pathways, such as shadowing features.

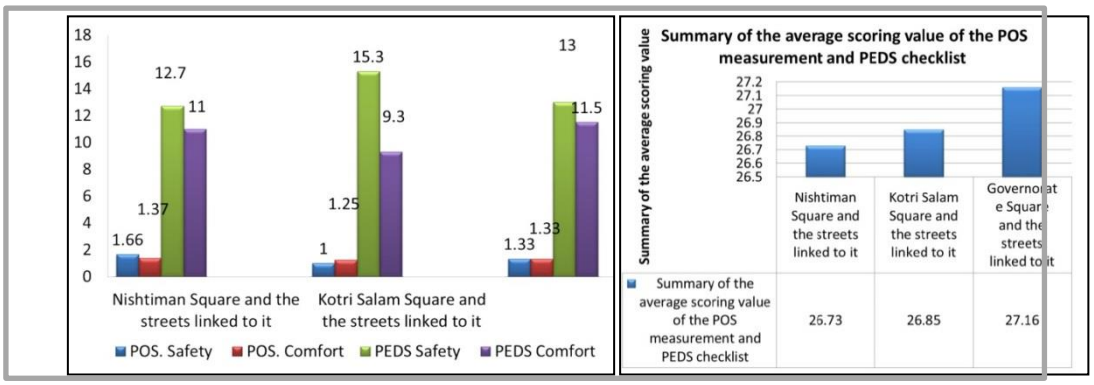


Fig. 5: Summary of the average scoring value of the POS measurement and PEDS checklist.

Finally, the final scoring value for each subsystem is calculated by the summation of both (POS measurement checklist for squares and PEDS checklist for streets) as shown in Appendix. 10. Based on the results, Governorate Square and the streets linked to it came in 1st place, while Nishtiman subsystem 2nd and Kotri Salam subsystem 3rd, Thus, theoretically, the Governorate subsystem is considered the most walkable among the studied area.

4.2.Outcomes and discussing the Questionnaire Survey:

4.2.1. Analyzing user satisfaction levels on the walkability indicators in public open spaces in Erbil city center:

A comparison of the degree of satisfaction of the people in Erbil city center's POS was done in this study by using a subjective assessment of a face-to-face questionnaire survey as shown in **Table 6**. For this reason, a statistical test was conducted, and the mean value for each indicator was calculated. Thus, the highest value was recorded in the safety of the squares while the lowest was

recorded in comfort in the squares ,see**Appendix.5** .The outcomes of the one-sample t-test ensures that choosing the walkability indicators or factors, namely safety, and comfort can be examined variables in the studied POS in ECC.

4.2.2. Analyzing walkability indicators' correlation in public open spaces in Erbil city center:

Analyzing the correlation between studied public open spaces in Erbil City Center and their walkability was achieved by using Pearson Correlation analysis to walkability indicator results as shown in **Appendix.6**.Based on the Pearson Correlation value, there is a highly significant correlation between walkability indicators in streets and the squares in public open spaces in ECC.

4.2.3. Comparison between the outcomes of the objective measurements (PEDS checklist, POS

measurement checklist) and the subjective measurement (questionnaire survey) results.The Independent Sample t-test was used and a statistical comparison was conducted through the abovementioned test and the mean value for each indicator was found in both measurements. Then the means of each indicator in objective measurement were comprised of its mean in subjective measurement, and a significant value for each indicator was calculated.

Based on the comparison outcomes, it is revealed that there is no significant difference between the outcomes of the subjective (questionnaire) and objective (PEDS checklist, POS measurement checklist) measurement tools in the safety and comfort indicators studied. Thus, the final hypothesis has been accepted. This means the outcomes of both measurement tools ensure the dependability and reliability of the used spatial checklists for analyzing and questionnaire in measuring the evaluating walkability, as shown in **Appendix.7**

5.0 Conclusions:

The following results were obtained from analyzing the selected case studies:

1. Based on the spatial analysis result, the highest recording value was in the Governorate subsystem while the lowest was in the Nishtiman subsystem. However, the people that attended Nishtiman were the most as compared to other case studies based on the observation. There should be many factors that caused this result, such as the socio-demographic background of the users or the identity of Nishtiman Square itself, or its location.
2. The highest recorded average value for subjective assessment (questionnaires survey) for all studied areas was recorded in Nishtiman Subsystem, while the minimum recording went to the Governorate, and also the results were homogeneous generally, which may be related to the respondents' socio-demographic factors.
3. Even though there is a lack of some major facilities in public open spaces in Erbil city center that affect pedestrians' level of comfort and safety, such as shading the walkways and a lack of crossing signs, the results revealed that they are safe and comfortable for walking generally.3. The outcomes of the one-sample t-test revealed that there is a highly significant difference among the users' satisfaction levels in all study areas on walkability indicators that are studied in the existing study. Thus, the results ensure that choosing the walkability indicators or factors, namely safety, and comfort can be examined variables in the studied POS in Erbil city center. This confirms the reliability of 1st hypothesis.
4. Based on the Pearson Correlation analysis, there is a highly significant correlation between walkability indicators in streets and the squares, this confirms the reliability of chosen factors and the validity of 2nd hypothesis.
5. Based on the comparison outcomes of the ' Independent Sample t-test ', it is revealed that there is no significant difference between the outcomes of the subjective (Questionnaire) and objective (PEDS checklist, POS measurement checklist) measurement tools in the safety and comfort indicators studied. Thus, the final hypothesis has been accepted. This means the outcomes of both measurement tools ensure the dependability and reliability of the used spatial checklists for analyzing and questionnaire in measuring the evaluating walkability.
6. Even though there is a lack of some major facilities in public open spaces in Erbil city center that affect pedestrians' level of comfort and safety, such as shading the walkways and a lack of crossing signs, the results revealed that they are safe and comfortable for walking generally.

6.0 Recommendations:

1. The current study's outcomes can assist and contribute to the diagnosis of deficiencies in current public open spaces in Erbil city center, providing a piece of trustworthy information for prospective walking system projects to prevent the recurrence of design faults.
2. Finally, when constructing streets and squares, specific characteristics (such as the segment intersections, sidewalk connection, degree of enclosure from the surrounding, articulation of the buildings, lighting, walking obstacles, and crosswalks) should be taken into account. The level of safety in walking can be increased by well-maintained sidewalks and the availability of crossing devices on the majority of routes between public users' living places and their targeted public open spaces. Walkability can be achieved by creating a built environment setting that allows pedestrians to decrease their reliance on cars, reduce air pollution, foster a feeling of togetherness, and enhance their amount of body activity. In addition, based on the results, the authors advise that for open public spaces to be productive, they should work to implement many services that can draw people in, all of which are used continuously and indefinitely and routinely maintained to encourage people to stay there and enjoy the beautiful landscape.

Acknowledgments:
The authors want to express their sincere appreciation to the people of Erbil city without whom this study could not have been completed.

Conflicts of interest:
The authors explain that there are not any conflicts of interest in the existing study.

Questionnaire form

Study area : No. of form:

Please select one of the five choices below for section A and B

Score Ranking Description

Strongly Disagree(SD):1 Disagree(D):2 Nutral(N):3 Agree (A):4 Strongly Agree (SA):5

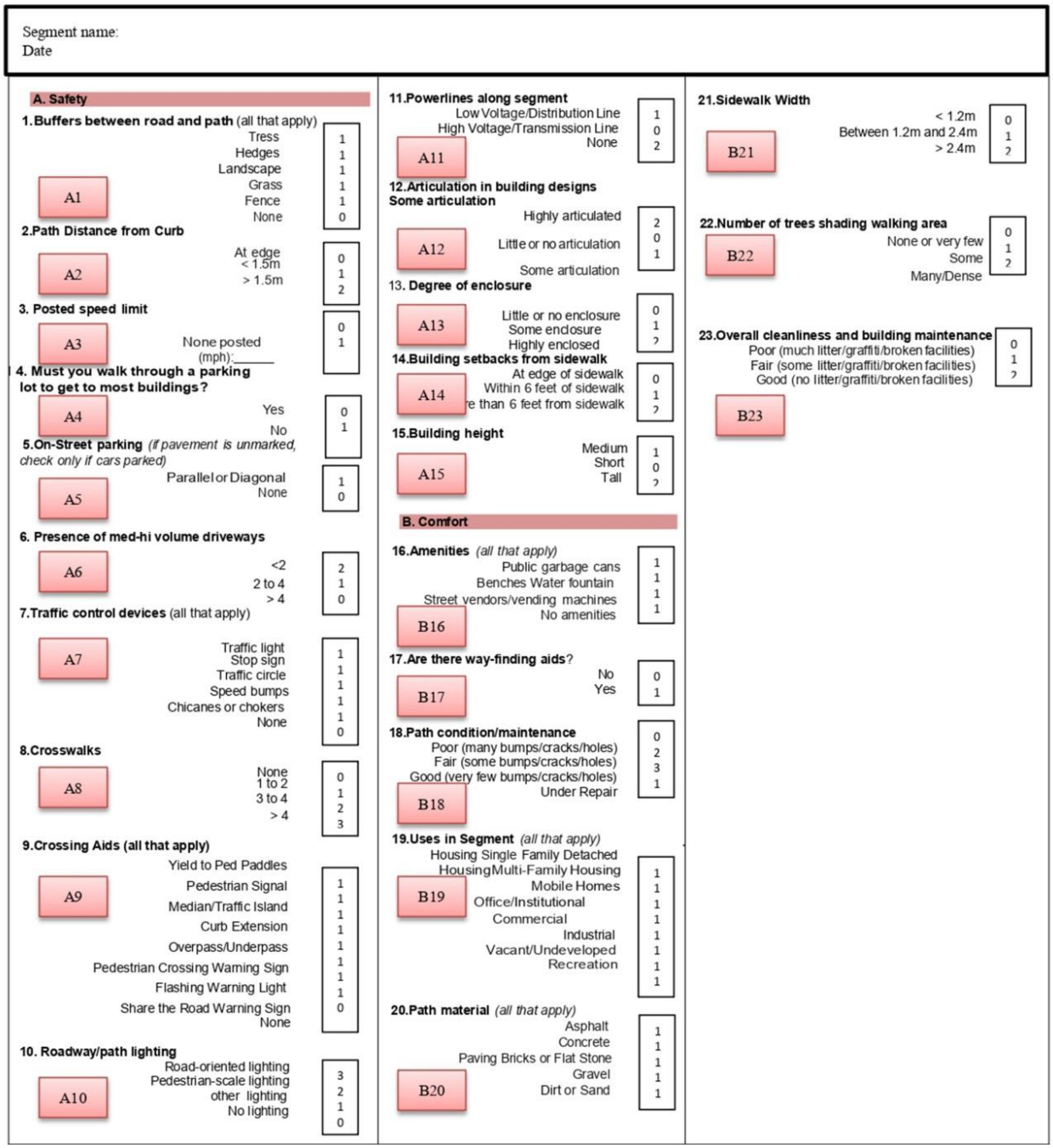
A. Streets linked to the squares

No	A-Safety	1	2	3	4	5
1	This street is not intersected by vehicles.					
2	The pavements are not slippery and they are safe to use for walking.					
3	In this street lightening aspect and crossing, signs are quite giving a good sense of security.					
4	The presence of people on the sidewalks creates a good feeling of safety.					
5	The width of the sidewalk and pathway are good and each person has enough space that gives a good sense of security.					
6	This is welcoming place for everyone.					
7	Shops and other places are around this street which gives a sense of safety.					
No	**B-Comfort**	1	2	3	4	5
1	The height and dimensions of the sidewalks, and pathways are comforting to use on this street.					
2	In this street, the variety of surrounding such as shops and restaurants creates a good sense of comfort.					
3	The presence of shadowing elements on the sidewalks and pathways gives a sense of comfort to this street.					
4	The availability of pedestrian crossing and signs on this street gives a sense of comforting					
5	The overall cleaning in this street gives a sense of comfort.					

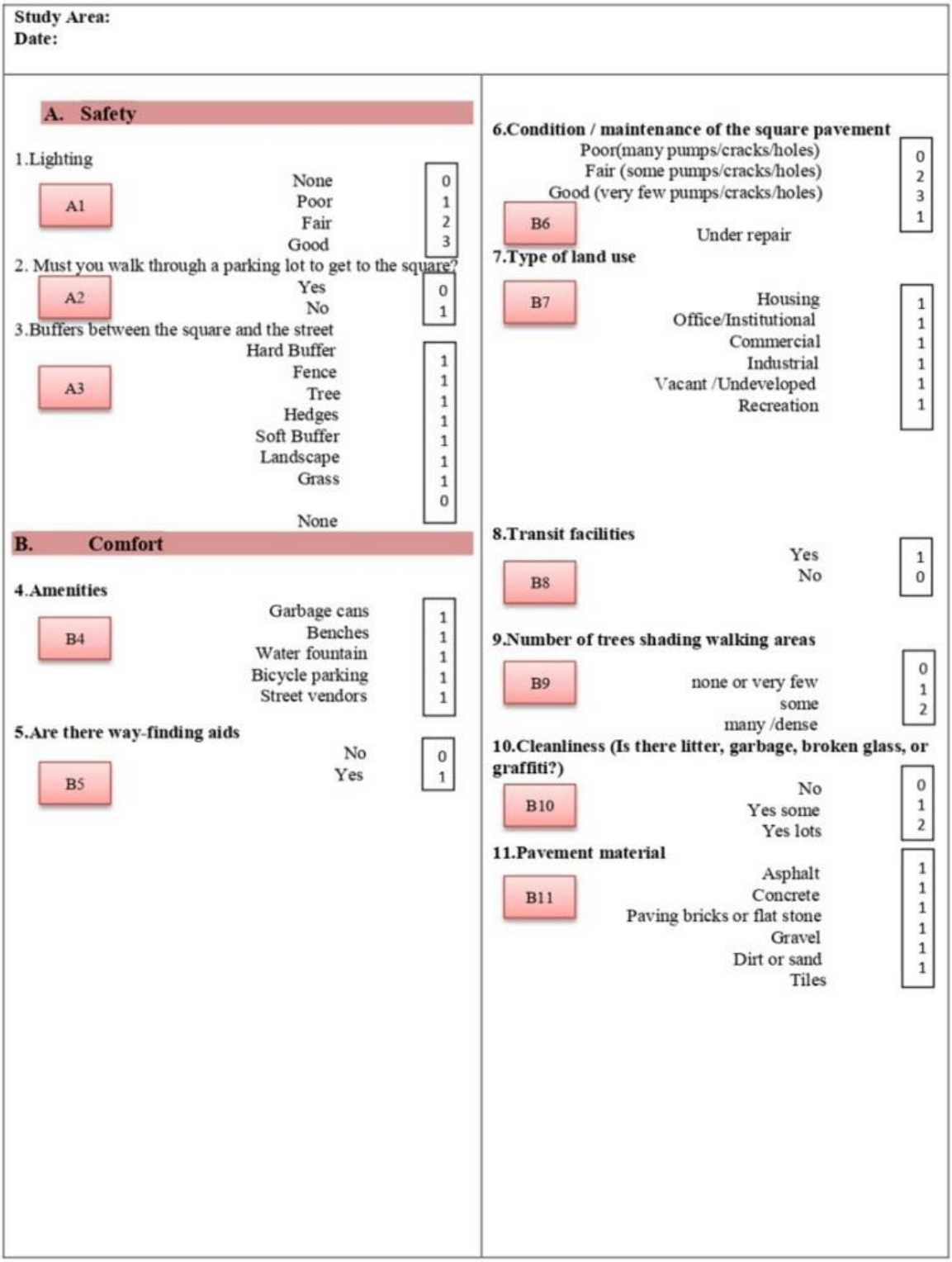
B. Square

No	A-Safety	1	2	3	4	5
1	Vehicles are not allowed and this quite gives a good sense of security.					
2	The pavement is not slippery and they are comfortable to use for walking .					
3	Lightening aspects are quite giving a good sense of security in the square.					
4	The presence of shops and other places are around the square gives a sense of the safety					
5	The presence of people in the square makes a good feeling of safety.					
6	This square is a welcoming place for everyone					
No	**B-Comfort**	1	2	3	4	5
1	The availability of benches and sitting creates a good sense of comfort in the square.					
2	The variety of surrounding such as shops and restaurants creates a good sense of comfort in the square.					
3	The presence of shadowing in the square gives a sense of comforting.					
4	Public toilet availability near the square giving the sense of comforting					
5	The overall cleaning of the square gives a sense of comforting					

Appendix.1:Questinnire survey form(Researchers)



Appendix.2:Modified PEDS checklist for streets(Researchers)



Study Area:
Date:

A. Safety

1.Lighting

A1

None	0
Poor	1
Fair	2
Good	3

2. Must you walk through a parking lot to get to the square?

A2

Yes	0
No	1

3.Buffers between the square and the street

A3

Hard Buffer	1
Fence	1
Tree	1
Hedges	1
Soft Buffer	1
Landscape	1
Grass	1
None	0

B. Comfort

4.Amenities

B4

Garbage cans	1
Benches	1
Water fountain	1
Bicycle parking	1
Street vendors	1

5.Are there way-finding aids

B5

No	0
Yes	1

6.Condition / maintenance of the square pavement

B6

Poor(many pumps/cracks/holes)	0
Fair (some pumps/cracks/holes)	2
Good (very few pumps/cracks/holes)	3
Under repair	1

7.Type of land use

B7

Housing	1
Office/Institutional	1
Commercial	1
Industrial	1
Vacant /Undeveloped	1
Recreation	1

8.Transit facilities

B8

Yes	1
No	0

9.Number of trees shading walking areas

B9

none or very few	0
some	1
many /dense	2

10.Cleanliness (Is there litter, garbage, broken glass, or graffiti?)

B10

No	0
Yes some	1
Yes lots	2

11.Pavement material

B11

Asphalt	1
Concrete	1
Paving bricks or flat stone	1
Gravel	1
Dirt or sand	1
Tiles	1

Appendix.3: POS(Public open space) measurement checklist for squares(Researchers)

Observation elements	Nishtiman square and the streets linked to it	Kotri Salam square and the streets linked to it	Governorate square and the streets linked to it
Number of people	150	63.5~64	29
No. of Male	133.5~134	52.5~53	25.5~26
No. of Female	18.5~19	11.5~12	4.5~9
No. of People using walking stick	0.5~1	1	0.2~1
No. of People using wheelchair	1	0.5~1	1.5~2
Walking	87.5~88	10.7~11	10.5~11
People walking alone	53.5~54	9.5~10	3.5~4
People having a company	33	9	5.5~6
People in groups	2.5~3	4.5~5	2
Group size(Person/Group)	1.5p/0.5gr~2p/1gr	3p/1.5gr~3p/2gr	2 p/0.5gr~2p/1gr
Sitting	41	22	12
People sitting alone	21.5~22	8	4.5~5
People having accompany	14.5~15	7.5~8	9.5~10
People sitting in groups	5	7	2.5~3
Group size(Person/Group)	2.5p/1.5gr~3p/2gr	3.5p/2gr~4p/2gr	2p/0.5gr~2p/1gr
Standing	21.5~22	19.5~20	5.5~6
Standing alone	8	6.7~8	2
Standing with a person	11.5~12	8	3.5~4
Standing in group	2.5	5.5~6	0.5~1
Group size(Person/Group)	1p/1gr	2.5p/1.5gr~3p/2gr	0.2p/0.2gr~1p/1gr
Running	0.5~1	1	1
Running alone	1	1	0.7~1
Running with a person	0	0	0.2~1
Running in group	0	0	0
Group size(Person/Group)	0	0	0

Appendix.4: The total average of the three studied areas' observation results (during four different seasons from October 2021 to June 2022) ((Researchers))

Case study	The average number of users based on photo-analysis observation	How to calculate sample size	The sample size (No. of forms for distributing)
Nishtiman Square and the streets linked to it	150 people/Hour	150*12h=1800 1800*10%=180people/Day	180form/studying area
Kotr Salam Square and the streets linked to it	64 people/Hour	64*12h=768 768*10%=76.8~77people/Day	77form/studying area
Governorate Square and the streets linked to it	29 people/Hour	29*12h=348 348*10%=34.8~35people/Day	35form/studying area

Appendix.5: Details of the calculated sample size and the number of questionnaire forms in each studying area (Researchers)

Factors	N	Mean	SD	%Agreement
Safety at streets	292	3.7666	0.72233	75.33%
Comfort at streets	292	3.4697	0.68720	69.39%
Safety at squares	292	4.1256	0.47466	82.51%
Comfort at squares	292	3.4637	0.65166	69.27%

Factors	N	Mean	SD	t-test	p-value
Safety at streets	292	3.7666	0.72233	18.136	0.000**
Comfort at streets	292	3.4697	0.68720	11.679	0.000**
Safety at squares	292	4.1256	0.47466	40.521	0.000**
Comfort at squares	292	3.4637	0.65166	12.159	0.000**

**Significant at level (p<0.05)

Appendix.6: One sample t-test for walkability indicators in Erbil city center's public open spaces

Walkability indicators	Method	Safety at squares	Comfort at squares
Safety at streets	Pearson Correlation	.295**	
	Sig. (2-tailed)	0.000	
Comfort at streets	Pearson Correlation		.310**
	Sig. (2-tailed)		0.000

**. Correlation is significant at the 0.01 level (2-tailed)

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix.7: Pearson's correlation to walkability indicators

Measurements		N	Mean	SD	t-test	P-value
Safety	Subjective	292	3.95	0.49	1.561	0.120
	Objective	3	3.50	1.00		
Comfort	Subjective	292	3.47	0.54	-0.636	0.525
	Objective	3	3.67	0.58		
*Significant at level (p<0.05)						

Appendix.8: Independent Samples t-Test Comparison of the outcomes of the subjective and

Study area	A1	A2	A3	Total	Average	B4	B5	B6	B7	B8	B9	B10	B11	Total	Average	Total	Total Average
Nishtiman Square	3	0	2	5	1.66	4	1	3	1	1	0	0	1	11	1.37	16	3.03
Kotri Salam Square	2	1	0	3	1	3	0	3	1	1	0	1	1	10	1.25	13	2.25
Governorate Square	3	1	0	4	1.33	4	0	3	1	1	1	0	1	11	1.33	15	2.66

N.S: Nishtiman Square; **K.S.S**: Kotri Salam Square; **G.S**: Governorate Square

A. Safety: A1. Lighting ; A2. Must you walk through a parking lot to get to the square?; A3 Buffers between the square and the street

B.Comfort:B.4. Amenities;B.5. Are there way-finding aids; B.6. Condition / maintenance of the square pavement ; B7. Type of land use ;B.8. Transit facilities ;B.9.Number of trees shading walking areas; B.10.Cleanliness(Isthere litter garbage graffiti?) B.11. Pavement material

Appendix.9: POS measurement checklist's results for squares

Study area		A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	Total	B16	B17	B18	B19	B20	B21	B22	B23	Total	Total
Streets linked to the Nishtiman square	N.S.(A)	2	2	0	0	1	2	0	0	1	2	1	0	1	0	2	14	3	1	1	1	1	1	0	1	9	23
	N.S.(B)	2	0	0	1	0	2	0	0	1	5	1	1	1	0	1	15	3	0	3	1	1	1	0	2	11	26
	N.S.C(C)	0	0	0	0	1	2	1	1	1	5	2	1	0	0	0	14	3	1	3	1	1	1	0	2	12	26
	N.S.(D)	0	0	-	-	-	-	-	-	-	5	1	0	1	0	1	8	3	0	3	1	1	2	0	2	12	20
Total		4	2	0	1	2	6	1	1	3	17	5	2	3	0	4	51	12	2	10	4	4	5	0	7	44	
Average		1	0.5	0	0.2	0.5	1.5	0.2	0.2	0.7	4.2	1.2	0.5	0.7	0	1	12.7	3	0.5	2.5	1	1	1.2	0	1.7	11	23.7
Streets linked to the Kotri Salam square	K.S.S.(A)	0	0	1	1	2	2	0	0	0	3	0	2	2	0	3	16	2	0	2	1	1	1	1	0	8	24
	K.S.S(B)	0	0	0	1	0	2	0	0	1	3	2	2	2	0	2	15	2	1	3	1	1	1	0	2	11	26
	K.S.S(C)	1	0	0	1	0	1	0	1	1	3	2	2	2	0	2	15	2	1	2	1	1	1	0	1	9	24
Total		1	0	1	3	2	5	0	1	2	9	4	6	6	0	7	46	6	2	7	3	3	3	1	3	28	
Average		0.3	0	0.3	1	0.6	1.6	0	0.3	0.6	3	1.3	2	2	0	2.3	15.3	2	0.6	2.3	1	1	1	0.3	1	9.3	24.6
Streets linked to the Governorate Salam square	G.S.(A)	1	0	0	0	1	2	0	0	1	3	1	0	2	0	2	12	2	0	2	1	1	1	2	2	11	23
	G.S.(B)	1	0	0	0	1	2	0	0	1	3	1	2	2	0	2	14	2	1	2	1	1	1	2	2	12	26
Total		2	0	0	0	2	4	0	0	2	6	2	2	4	0	4	26	4	1	4	2	2	2	4	4	23	
Average		1	0	0	0	1	2	0	0	1	3	1	1	2	0	2	13	2	0.5	2	1	1	1	2	2	11.5	24.5

N.S: Nishtiman Square; K.S.S: Kotri Salam Square; G.S: Governorate Square

N.S.(A).Street **A** linked to Nishtiman square; N.S.(B). Street **B** linked to Nishtiman square; N.S.C(C).Street **C** linked to Nishtiman square;

N.S.(D). Street **D** linked to Nishtiman square; K.S.S.(A). Street **A** linked to Kotri Salam square; K.S.S(B). Street **B** linked to Kotri Salam square; K.S.S(C). Street **C** linked to Kotri Salam square ; G.S.(A). Street **A** linked to Governorate square; G.S.(B). Street **B** linked to Governorate square

A. Safety: A1. Buffers between road and path; A2.number of lanes;A3.Posted speed limit;A4. Must you walk through a parking lot to get to most buildings?;A5. On-Street parking;A6. Presence of med-hi volume driveways ;A7. Traffic control devices;A8. Crosswalks;A9. Crossing Aids;A10. Roadway/path lighting;A11. Powerlines along segment;A12. Articulation in building designs Some articulation;A13. Degree of enclosure;A14. Building setbacks from sidewalk;A15. Building height.

B. Comfort:B16. Amenities: B17. Are there way-finding aids; B18. Path condition/maintenance; B19. Uses in Segment;B20. Path material;B21. Sidewalk Width;B22. Number of trees shading walking area ;B23. Overall cleanliness and building maintenance.

Appendix.10: PEDS measurement checklist's results for streets

Studying areas	Objective measurement results				
	POS measurement checklist indicator results.		PEDS checklist indicator results.		Summary of the subsystem's average scoring value of the objective measurements
	Safety	Comfort	Safety	Comfort	
Nishtiman Square and the streets linked to it	1.66	1.37	12.7	11	26.73
Kotri Salam Square and the streets linked to it	1	1.25	15.3	9.3	26.85
Governorate Square and the streets linked to it	1.33	1.33	13	11.5	27.16

Appendix.11: Summary of the each subsystem's objective measurement scoring

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