The Impact of Accessibility and Connectivity On Walkability in Public Open Spaces at City Center of Erbil

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Doi: 10.23918/eajse.v9i1p173

Abstract: Among the most important aspects of any urban setting is walkability. City centers and their open public spaces have an important role in walkability. There is a shortage of scientific evidence and understanding of walkability in terms of public open space in Erbil's city center. Thus, this study investigated the relationship between walkability and streets and also studied the factors that impact walkability by using an objective PEDS checklist, UCL Depth map software, and subjective questionnaire in nine streets that connected to three squares lied in the heart of Erbil's city. From the findings, it is revealed that Governorate square's streets are regarded as being the most walkable and Erbil's central streets are generally accessible and connective for a walking experience, despite the absence of some key amenities which have a significant impact on accessibility and connectivity.

Keywords: Walkability, Accessibility, Connectivity, PEDS Checklist, Pedestrian Satisfaction

1. Introduction

For centuries, walking and city center activities have been linked (Jacobs, 1961), Grignaffini (2008) defined 'walkability' as the simplest method of transportation and it determines how a place is reachable and convenient to pedestrians. While Abley (2005) described walkability as the measure by which a place's urban environment promotes the existence of people who live, go there for retail, visit, enjoy it, or spend time there, which mirrors the modernized definition of public open spaces. Several designers in urban areas have employed the idea of walkable public open space to convey "accessibility, comfort, proximity, and suitability."

The Kurdistan region's capital, Erbil, is expanding rapidly. Additionally, it is recognized as the Kurdistan region's capital of tourism. Therefore, the need to explore walkability in Erbil city center is increasing significantly, especially in the public open spaces of the city center because the most important aspect of a vibrant city is a public open area. It is a place that represents humanity's social hierarchy and prior beliefs. They tend to be areas where one may watch the transformations and modernization of civilization and also areas where people can socialize and be encouraged to walk.

2. Review of Literature

2.1 Key Factors of Walkability

A decent life quality entails better health, financial security, social cohesiveness, a secure environment, and clean air. The majority of these may be found in a walkable city (Gehl, 2010).

Received: July 26, 2022
Accepted: December 1, 2022
Nury, S.A., & Haykal, H.T., (2023). The Impact of Accessibility and Connectivity On Walkability in Public Open Spaces at City Center of Erbil. *Eurasian Journal of Science and Engineering*, *9*(1), 173-196.

Walkable public open space provides city centers with liveliness and assists in healthier urban environments (Abdullah, 2019). Several researchers have attempted to define the key factors that affect walkability.

The Government of West Australia (2007) initiative 'Walks WA: A Walking Strategy for Western Australia (2007-2020)' provided a good overview, which included a conceptual perspective and also tangible ideas according to approach, five factors must be regarded to create a walkable environment (Abdullah, 2019):

1. Accessibility and access: Providing everybody with easily accessible roads by foot, and also assuring the provision of amenities that could assist the disabled and elderly. (Abdullah, 2019).
2. A landscape must have permeability, a degree of movement or easy accessibility, which would be managed by obstacles, suitability, and ease of access (White, 1990)
3. Aesthetics: The requirement to create a situation that provides a good feeling in the place by paying attention to the landscape arrangement and also disposal management.
4. Walkers should feel completely safe, both in terms of themselves and their things. Walkers must also be able to experience their journey comfortably, in an atmosphere that is kept safe through the use of design concepts that prevent violence. Pavements, higher medians, improved bus station location, slowing traffic techniques, and services for impaired travelers are all examples of measures that ease the roadway for walkers, and enhances pedestrian safety (Southworth, 2005).
5. Comfort: Walkers ought to be allowed to walk down the street comfortably, with amenities like communal seats and covers, and access to safe drinking water. (Abdullah, 2019).

According to Ali and Ali (2018), public open spaces must be friendly and healthy enough to accommodate people's diverse actions; they must be connected properly to other areas instead of being divided into different parts, allowing participants to interact in spontaneous actions.

Several studies have studied the relationship between walking activity and the diversity of environmental parameters. Several investigations placed a greater emphasis on the parameters of the physical environment and the design of roads than on user perceptions (Abdullah, 2019). While others concentrated on subjective aspects of walkability in the physical environment, such as accessibility, proximity to nearby destinations, attractiveness, traffic and road safety risks, and connectivity, and that it relates to how users feel about infrastructures (Nyagah, 2015).

There are some common factors and features observed in evaluations of walking public areas. Numerous studies suggest that certain aspects of built environments could affect people's walking in public open spaces (Jacobs, 1961).

To sum up, the term 'walkability' has been used repeatedly in the studies of urban planners and landscape architects. The role of walkability in defining a better pedestrian environment has been studied in various fields (Abdullah, 2019). They all concluded that some characteristics of the environmental fabric had a considerable influence by encouraging or discouraging of the walking behavior of the pedestrians. Several studies have investigated the relationship between walking activity and the diversity of environmental parameters. Several investigations placed a greater emphasis on the parameters of the physical environment such as accessibility, connectivity, proximity, safety and the design of roads than on user perceptions (Abdullah, 2019). There are some common factors and features observed in evaluations of walking public areas. Numerous studies suggest that certain aspects of built environments could affect walking in public open spaces.

(Jacobs, 1961).

2.2. Previous Researches

The study of Salam et al. (2020) tried different methods to measure factors that motivate people to walk. They used questionnaires and site observation and SWOT analysis. The study was organized into three major components to explore the characteristics of the current urban society. As a case study, Salem's street was chosen to analyze its potential as a pedestrian-friendly street. The study's final section offers suggestions and advice on how to encourage people to walk in today's society. The most important factors considered in this study were accessibility factors, street dimensions, orientations, climate situations, removal of barriers, connectivity factors, particular design, lighting, and safety factor.

In Abdullah's study, set in Libyan cities, because of the un walkability of public open spaces in urbanized centers and the shortage of related legislation, the authors try to evaluate the environment's quality, the population's perception, and their interaction with public open spaces. The study used a qualitative method for the questionnaire obtained from site observation and the SPSS program used for analyzing the information gathered. The findings of the research can be used in planning urban areas to define walkable space aspects, which might help enhance the walkability in Libyan cities and build more livable and sustainable urban environments. According to this study, the most important factors for walkability were security and safety, and among them were criminal hazards, traffic flow security, street lights, the number of police officers on the street, and no evidence of people carrying guns.

Haykal and Abdullah's (2018) study focused on the impact of characteristics of street design on walkability and used a checklist of PEDSand UCL depth maps combined with site observation and SPSS software. The research's problem was the lack of the scientific evidences on walkability issue in residential neighborhoods in Erbil city. For this purpose, they examined the effect of five factors (5 walkability indicators) on walkability in two specific neighborhoods in Erbil city, and the results of the study were at the level of streets, there is no positive relationship between the number of intersections, connections of sidewalk with the numbers of pedestrians, while there was a strong positive correlation between the type of land use and enclosure of building and building articulation with the pedestrian numbers. The study categorized variables into two groups: subjective variables and objective variables. The results of the experimental study revealed that each of the variables studied influenced walking in various ways, and various sorts of neighborhoods had distinct effects on walking.

Amaar's study (2018), which focused on the city center of Alexandria, investigated the term walkability in his study as a measurable term in urban planning. As a result, the goal of this study was to establish a collection of walkability criteria in public areas that may be employed in applications that have a significant effect on the quality of the urban design through the using of field observation combined with questionnaire. Due to lack of public transport facilities and the high density of the traffic the pedestrians' movement was not comfortable to determine the main indicators that caused these situation, this study examined the walkability of four separate street zones, identifying their walkability limits, issues, and opportunities. The walkability variables that were determined according to the author were accessibility, attractiveness, safety, the pattern of the street, quality of the street, connectivity, linking with other open spaces, and the finding was that the most walkable zone was that with an attractive streetscape and scenery, historic bodies, and the

existence of services of the streets.

According to Shamsuddin and Bilyamin 's (2014) study, walking is frequently ignored as a method of transportation, and there aren't many analytical tools available to assist professionals in identifying walking settings that meet acceptable standards, for this reason, the study by using a mixed-method questionnaire and observing the site explored the factors that affected people's ability to walk in the city center. The results from the study showed that the walkability of the city center of Kuala Lumpur may be more developed by improving factors of physical and subjective or psychological. The study focused on linkage to surroundings, safety, comfort, recreation and enjoyment, and connection. Lastly, Table.1 provides a summary of the key factors affecting walkability, and public open space's design characteristics related to accessibility and connectivity based on different references summarized in Table. 2.

2.3. Research Problem

The study of walkability in public open spaces in the city center including streets and the relationships of accessibility and connectivity with walkability has not been studied until now due to a shortage of scientific evidence and understanding of walkability at the level of public open space in Erbil's city center. Therefore, this study trying to assess the relationship between walkability and factors that impact walkability.

2.4. Research Hypothesis

H1: There is a significant difference in user percentage agreement level of satisfaction on accessibility and safety in Erbil city center's streets.

H2: There is a significant difference between achieved walkability levels and accessibility and connectivity factors in Erbil city center's streets

- Based on the selected different case studies
- Based on the user's walking behavior in public open spaces in Erbil city center

H3: The correlation is significant between the studied indicators of walkability in the selected streets of Erbil city center.

3. Research Methodology

The face-to-face interview questionnaire survey will be used on visitors and walkers who were randomly chosen to be respondents (Creswell, 2007). Furthermore, this method was utilized to conduct the "National Survey of Pedestrians, 2002," since the randomized method can lessen potential biases. (Piaw, 2006). Combined with a part of the PEDS checklist that was modified by the researchers under the accessibility category as objective assessment (Appendix 7) and UCL Depth map software of public open spaces in Erbil city center areas, 9 streets from three locations were chosen in the heart of Erbil's city as study areas (the streets linked to Nishtiman Square, the streets linked to Kotri Salam Square, and the streets linked to Governorate Square) and this study's variables are summarized in(Table.3).

4. The Study's Scope

The study's scope encompasses two factors— accessibility and connectivity— and their impact on

walkability through the design characteristics of Erbil city center's public open spaces.

4.1. Factor of Accessibility

These factors provide ease of access to roads by walking and also assure the provision of amenities that can assist the aged and impaired (Abdulla, 2019). Obstructions, comfort, and access to landscapes should all be managed so that the area has a permeable degree of circulation or easy accessibility (Southworth, 2005). In addition, the accessibility of public open spaces must have a variety of uses for spaces and buildings, as well as high-quality routes, visible signs, and adequate pedestrian path widths (Gehl, 1987; Salam et al., 2020). Each of these elements is necessary to make walking easier and more enjoyable. According to Halden (2012), accessibility is determined by three factors: people's capability to transport or communicate (or the features of commodities for freight accessibility), the placement of opportunities and activity, and the provision of interconnections utilizing various modes of transportation. In this study accessibility is related to proximity to other destinations, pathways (Zakaria and Ujang, 2015; Rani et al,2018), access to public transport, proximity to roads, proximity to public transport station (Rani et al., 2018), easiness of using the public open space (Ali and Ali, 2019; Abdullah, 2019), sidewalks (Shamsuddin et al.,2012), security and comfort, obstacles, pedestrian movement, car flow, regulated lightening, and availability of parking (Radha et al.,2020).

4.2 Factor of Connectivity

According to Southworth (2005), streets that are well connected to other methods of travel make up a well-planned roadway system. Continuity of walkways, the safety of the pedestrian network, and proximity to locations could all help to increase connectivity (Southworth, 2005). Also according to Llewelyn and Davies (2000), better connection and access are important for successful progress.

Public open spaces must be friendly and healthy enough to accommodate people's diverse actions, and they must be connected properly to other areas instead of being divided into different parts, allowing participants to interact in spontaneous actions (Ali and Ali, 2018). In this study connectivity indicators are POS location, POS connectivity and intersections (Southworth, 2005), connection to public transport (Abdullah, 2019), connection to major roads, connection to diversity (Ali and Ali, 2019), and connection to the nearby destinations(Southworth2005), signs, and way-finding features to connect to nearby destinations. Finally, the main indicators of the current study are summarized in Table 3.

Table 1**:** Key factors affecting walkability (Researchers)

Factors affecting walkability				
Objective			Subjective	Environmental factors
Built environment factors			Personal factors	
City scale	Neighborhood scale	Public open space scale		
-Zone -Variety -Connection -Land use mixing -Density -Attractiveness	-Land use mix -Distance Proximity -Pattern of open spaces -Reachability or accessibility -Security design -Variety -Connection -Comfort	-Security -Width of street -Width of pathways -Amenities of sidewalk -visua:l facilities -ftmiture like lightening -Smrounding buildings -Vailability of infrasa11cnu·e -Cleaning and well being -Noise -Connection -Amenities -Space and distance between buildings -Setbacks -Widtl1 of pathways -Fuminue of space -Attractiveness -Orientation of buildings -Height of building ration to width of space -Building facades -Buffer zone -Accessibility -Linkage and connection -Density -Mixed land use -Comfort -Image and identity -Historical value	-Gender -Health -Distance factor -Mood or animde -Economic, cost factor -Family simation -Tin1e factor -Security and safety -Availability of cars -Having walking company comfy -social interaction -vitality -sense of belonging -walking pmpose	-Land topography -Climate condition

Table 2: Public open space's design characteristics related to accessibility and connectivity based on different references (Researchers)

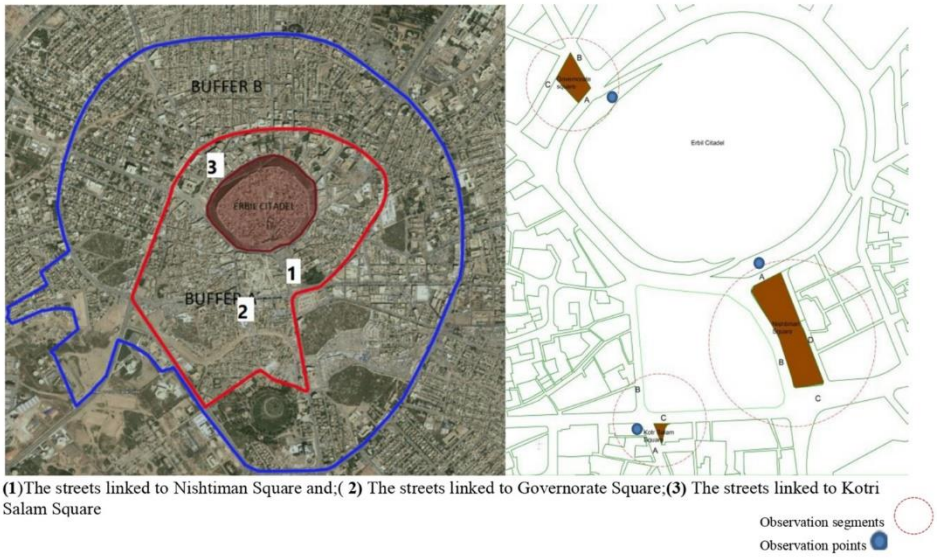
The reference	(Physical or POS design characteristics that related to the factors	Walkability factors related to the POS design characteristics
(Zakaria and Ujang, 2015) (Rani et alm,2018), (Radha et al,2020), (Ali and Ali,2019) (Abdullah, 2019) (Shamsuddin et al. ,2012)	Proximity to other destinations, access to public transport, easiness of using the POS, Proximity to roads, Pathways, Sidewalks,), Security and comfort, Obstacles, Cars flows, Pedestrian movement , Regulated lightening, Proximity to public transport station, Availability of parking, Cars flows, Pedestrian movement , Regulated lightening	Accessibility
(Southworth2005), (Abdullah, 2019), Ali and Ali,2019), (Southworth2005)	POS location, POS connectivity and intersections, Connection to public transport, connecting to major roads, connecting to diverse, connecting to the nearby destinations, Signs, and way-finding features to connect to nearby destinations.	Connectivity

Table 3: walkability indicators of the present study (Researchers)

Walkability (Dependent variable)	
Walkability variables of the research(Independent variables)	
Accessibility variable	Connectivity variable
Sub-variables: (Proximity to other destinations, Proximity to roads,), Proximity to public transport station, pathways, Availability of parking(Radha et al,2020) (Zakaria and Ujang, 2015) (Rani et al,2018), access to public transport, Regulated lightening (Radha et al,2020), easiness of using the POS, Security and comfort, Obstacles, Cars flows,Pedestrian movement(Abdullah, 2019) (Ali and Ali,2019) (Abdullah, 2019), Sidewalks (Shamsuddin et al. ,2012),.Cars flows, Pedestrian movement , Regulated lightening	Sub variables: POS location, POS connectivity and intersections(Southworth2005), Connection to public transport(Abdullah, 2019), connecting to major roads, connecting to diverse(Ali and Ali,2019), connecting to the nearby destinations(Southworth2005), Signs, and way- finding features to connect to nearby destinations.

5. Case Studies

In the Erbil city center areas, nine streets from three locations were chosen by employing random cluster sampling since, a cluster-sample method may be the only feasible solution when choosing a basic reflective sample of participants across the research area might be impossible (Bennett et al., 1991). The selected areas are: the streets linked to Nishtiman Square, the streets linked to Kotri Salam Square, and the streets linked to Governorate Square. Thus 9 streets will be studied and all of them are located in Erbil city center's Buffer Zone –A. Figs. 1&2 In addition, the main idea behind the size of the sample should represent 10% of the size of the entire group of population. Therefore, the number of the identified samples must not be below a hundred and not above a thousand samples of the overall population, otherwise, it causes time and financial wastage (Taherdoost, 2017). Consequently, (292) participants were asked questions, and (292) questionnaires were handed out, including (35) in the streets connected to the Governorate Square, (77) in the streets linked to Kotri Salam Square, and (180) in the streets connected to Nishtiman Square, based on the observations (Appendix 8) made for these areas.



(1) The streets linked to Nishtiman Square and;(**2)** The streets linked to Governorate Square;**(3)** The streets linked to Kotri Salam Square

Figure 1: chosen street's location in Erbil's city center, (Researchers)

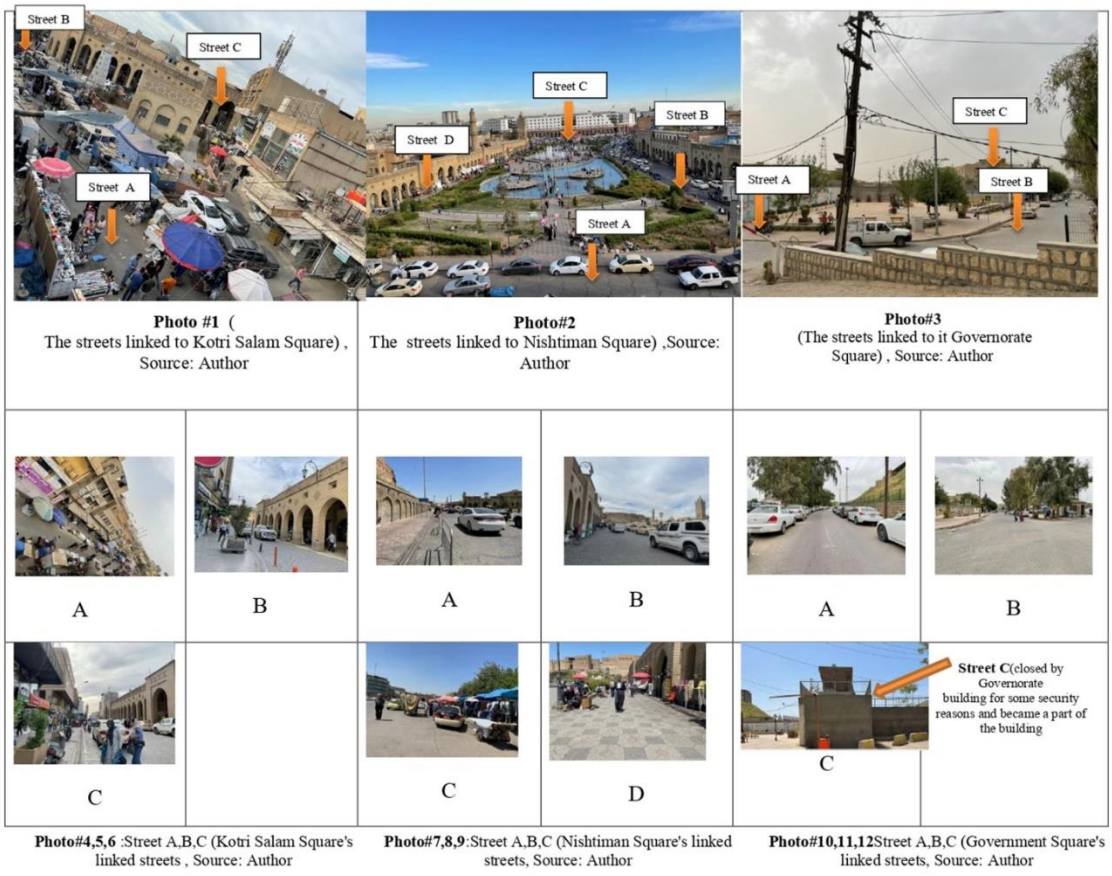


Figure 2: Photos and location of existing situation of segments' selected streets in Erbil's city center (Researchers).

6. Outcomes and Discussions

6.1 Analyzing and Discussing Streets' Accessibility Indicators by PEDS Checklist

Accessibility indicators are evaluated by calculating the scored average value for its sub-indicators A1 to A8 for each case study for each studied area, to identify the final score value which expressed this indicator, as shown in Fig.3, Appendix.2

Streets with the highest-scoring average mean have more accessibility characteristics and, theoretically, are considered to be much more walkable than the lower-scoring ones. Fig.3A, is the average scoring value of the streets linked to the squares in three examined areas: the streets linked to Nishtiman Square (13.2), the streets linked to Kotri Salam Square (14.6), and finally, the streets linked to the Governorate Square (17.5).

The outcomes reveal that among the studied areas, the highest-scoring records in accessibility are recorded in the streets linked to Governorate Square, with an average score of 17.5. This result relates to the POS design characteristics that are related to accessibility indicators, such as the good condition of the streets and the pathways, the surrounding facilities, and freeness from obstructions and barriers in front of the walkers during their walking experience in these streets, and theoretically, these streets seem to be more walkable. Finally, the availability of parking facilities for pedestrians, while the streets linked to Nishtiman Square scored the lowest average score of (13.2), and theoretically, these streets seemed to be less walkable, despite their good quality and condition,

because of the lack of some of the major facilities for pedestrians, such as bicycle lane pathways and poor parking facilities and the presence of barriers in front of the walkers during their walking experience. Finally, in the streets linked to Kotri Salam Square, due to the lack of parking facilities for pedestrians, and the presence of some obstructions in front of them, these streets came second place in scoring among the other streets linked to other squares.

6.2 Analyzing and Discussing the Streets' Connectivity Indicator Through UCL Depth Map Software

In this study, UCL Depth map software was used to measure the connectivity indicator for each case study. This software creates an axial map for each area, and it is colored with various colors according to the degree of connectivity. The lines with dark blue colors have the lowest value of connectivity, while warm-colored lines such as red have the highest value of connectivity. Also, the calculation of the connectivity values is represented by numbers from (0 to n).

For connectivity to determine which areas are more walkable the researcher calculated the average value of the connectivity for each Fig. 3B. The results show that among the studying areas the highest-scoring record for connectivity is recorded in the streets linked to Governorate which is 13.7 because it owns the most points of connection. And provide a comfortable environment for walking because streets are wide with no dead ends, Also the features that are available in the Governorate square are theoretically presumed to encourage walking, while the minimum scoring record for connectivity is recorded in the streets connected to Kotri Salam square which is 5.5 because it has the minimum number of connection points and because it is a traditional area where streets are irregular and narrower than the other two areas. Practically this will make an unpleasant environment for walking. Also, the street vendors that exist in the area made the place crowded with carts and their goods narrowed the space for walking.

As for streets linked to Nishtiman square, it's score is 7.16. It is practically a vibrant hub for visitors without dead ends. Its streets are wide and there are large intersections. In addition, cars are allowed in the streets and that made it a bit unpleasant and uncomfortable for walking; this affected the safety of the walkers and decreased walkability. See Fig.4 & Appendices (4), (5), (6)

In summary to make a comfortable walking experience and to encourage walking, one can take benefit from these three different types of squares and the streets linked to them by reducing the number of cross intersections, widening the streets, and freeing areas from obstruction.

The total value of scoring of measurement methods is calculated by summing the results from the PEDS measurement checklist and UCL Depth map software for streets. According to the findings, streets linked to Governorate Square ranked first, followed by the streets linked to Nishtiman and the Kotri Salam streets. Therefore, according to the results of this study, Governorate squares streets regarded as being the most walkable. As illustrated in Fig. 4.

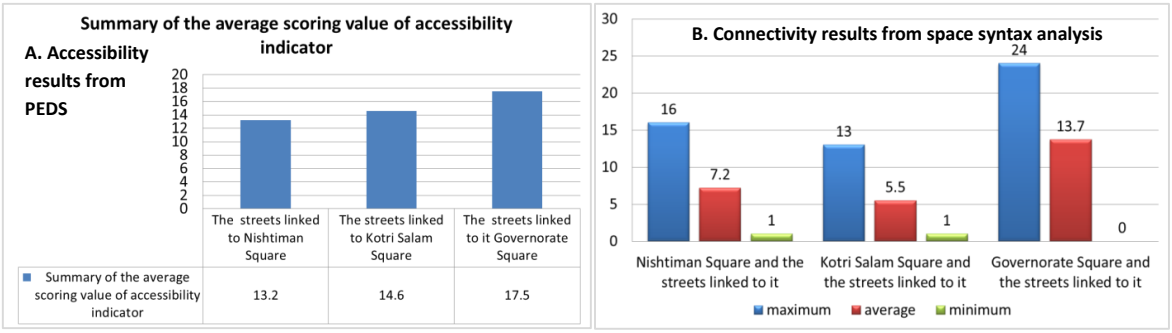


Figure 3: Accessibility and connectivity indicators' average scoring values for the studied streets Source: Author

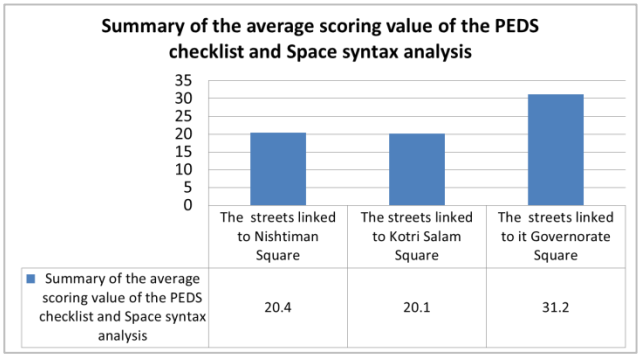


Figure 4: Summary of accessibility and connectivity indicators' average scoring values for the studied streets Source: Author

6.3 Outcomes and Discussing the Questionnaire Survey

6.3.1 Analyzing The Significant Difference in Users' Satisfaction Levels On the Walkability Indicators in Public Open Spaces in Erbil City Center.

Throughout this study, the level of satisfaction of users' at the open public space in Erbil's city center was compared using a subjective evaluation of a "face-to-face" survey questionnaires. The mean score for every indicator was derived as a result of a statistical test that was performed. According to the result, the accessibility of the streets recorded the greatest value at 3.8048 (71.24%.) Other values for accessibility at the streets were 3.5619 (76.10%) as showed in Tables 4&5.

There is a highly significant difference between the respondents' level of satisfaction across all the areas of study on walkability factors that are analyzed in the present study, as shown by the one-sample t-test results, which are t (16.495,18.790) at $p<0.05$ difference are highly significant and p-value=0.05 in all situations, thus the 1st hypothesis is accepted.

Consequently, the results confirm that accessibility and connectivity can be considered as evaluated factors while determining the walkability indications or elements in the open public spaces in studies in the heart of Erbil.

6.3.2 Correlation Analyzing Between Accessibility and Connectivity in Erbil City Center's Public Open Spaces

Through using analysis of Pearson Correlation to the outcomes of the walkability indicator, as shown in Table.6, it was possible to analyze the relationship between the examined street's walkability indicators in Erbil City Center and their walkability.

Calculating each indicator's value of significance was based on the values of the Pearson Correlation. As a consequence, the Pearson Correlation values for both accessibility and connectivity indicators in studied streets are (0.391**) and the p value was also equal in both relationships and p = 0.000 at the significant level, $p<0.05$. According to the findings, there is a strong correlation between walkability measures in streets and squares, thus the 2nd hypothesis is accepted. See Table. 6.

6.3.3 Investigating The Difference Between the Achieved Walkability in Erbil City Center's Studied Public Open Spaces

- Based on different selected case studies:

Analyzing the walkability difference between studied public open spaces in Erbil city center was done through the One-Way ANOVA test to test walkability indicator results in the first part, based on different selected case studies. For this reason, a statistical test was conducted, and the mean value for achieved walkability was calculated through their indicators in the streets linked to these squares streets. Thus, in the first case, the results of the ANOVA test were (F = 23.767 in streets) at the significant value of $p< 0.05$ accordingly walkability at streets has a statistically significant difference, so we accept the 3rd hypothesis (part 1), see Table 7.

- Based on users' walking behavior:

As for the second part of the hypothesis Independent sample t-test is used to walkability indicators based on the user's walking behavior and based on the results of the Independent Sample t-test (t = -0.691) in streets at the significant level of $p<0.05$, there is no significant difference between the achieved walkability in Erbil city center's studied public open spaces (streets) based on the user's experience (p-value =0.490) for streets. Thus the 2nd part of 3rd hypothesis is rejected, as shown in the table Table 8.

Finally, the outcomes revealed that the degree of walkability is changing in the city center of Erbil according to different selected streets as a part of public open spaces There is no significant difference between the achieved walkability in the studied public open spaces (streets) based on users' behavior; this may be related to the socio demographic background of the people or their experience in public open spaces in Erbil city center.

Table 4: Percentage of User's level of agreement on accessibility and connectivity in Erbil city center's streets

Factors	N	Mean	SD	%Agreement
Accessibility at streets	292	3.5619	0.58212	71.24%
Connectivity at streets	292	3.8048	0.73188	76.10%
****Significant at level (p<0.05)**				

Table 5: "One Sample t- test of "User's level of satisfaction on indicators of walkability in Erbil city center's streets

Factors	N	Mean	SD	t-test	p-value
Accessibility at streets	292	3.5619	0.58212	16.495	0.000**
Connectivity at streets	292	3.8048	0.73188	18.790	0.000**
****Significant at level (p<0.05)**					

Table 6: "Pearson Correlation" analysis of walkability indicators in Erbil city center's streets

Walkability indicators	Method	Accessibility at streets	Connectivity at streets
Accessibility at streets	Pearson Correlation		.391**
	Sig. (2-tailed)		0.000
Connectivity at streets	Pearson Correlation	.391**	
	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).**			
c. Listwise N=292			

Table7: One Way ANOVA"test to walkability difference in the streets in all studied areas

Item		N	Mean	SD	F- test	P -value
Walkability at streets	**Governorate streets**	35	3.73	0.353	23.767	0.000
	Kotri Salam streets	77	3.60	0.411		
	Nishtiman streets	180	3.93	0.347		
	Total	292	3.82	0.393		
*Significant at level p<0.05						

Table 8: "Independent Sample t-test "to walkability difference the streets in all studied areas based on the users' behavior

Items		N	Mean	SD	t-test	P-value
Street walkability	Users' walking behavior					
	Male	216	3.82	0.40	-0.691	0.490
	Female	76	3.85	0.38		
*Significant at level p<0.05						

Table 9: Summary of Accessibility and connectivity indicators' average scoring value for the studied streets (Source: Authors)

Studying areas	Objective measurement results		Summary of the average scoring value of the PEDS checklist and Space syntax analysis
	PEDS checklist indicator results.	Space syntax analysis's connectivity results	
	Accessibility		
The streets linked to Nishtiman Square	13.2	7.2	20.4
The streets linked to Kotri Salam Square	14.6	5.5	20.1
The streets linked to it Governorate Square	17.5	13.7	31.2

7. Conclusions

The following conclusions are drawn from this study's findings:

1. According to the objective measurement, the streets linked to Governorate Square have the highest recorded value, while Nishtiman Square's street recorded the lowest, although based on observation, Nishtiman Street had the highest number of users comparable to other case studies. Many factors, such as the users' socioeconomic backgrounds, Nishtiman Square's identity, or the positioning of the square, should have contributed to this outcome.
2. Additionally, the outcomes obtained from measurements generally were homogeneous, which might be explained by the participants' socio-demographic, social, and personal preferences or the positioning of all the studied streets within Erbil's Buffer Zone –A.
3. There is a highly significant difference between the respondents' level of satisfaction across all the areas of study on walkability factors that are analyzed in the present study, as shown by the one-sample t-test results. Consequently, the results confirm that accessibility and connectivity can be considered as evaluated factors while determining the walkability indications or elements in the open public spaces in studies in the heart of Erbil.
4. Moreover, the outcomes revealed that the degree of walkability is changing in the city center of Erbil according to different selected streets as a part of public open spaces. While there is no significant difference between the achieved walkability in Erbil city center's studied public open spaces (streets) based on users' walking behavior and this may be related to the socio-demographic background of the people or their experience in these streets in Erbil city center.
5. The results showed that Erbil's central public open spaces are generally accessible and connective for walking, despite the absence of some key amenities, such as parking facilities, bicycle facilities, bicycle lane, sidewalk and pathway maintenance, pedestrian crossing signs, and presence of obstacles, which have a significant impact on accessibility and connectivity.

7. Recommendations

1. The results of the present study can help and support the identification of shortcomings in the present public open spaces in the center of Erbil, offering a reliable reference for potential walking system projects to avoid the repetition of design problems.
2. While designing and planning streets, particular features (such as the segment intersections, walkway connections, linkages with surroundings, proximity to the public transport system, walking barriers, and crossing aids) must be brought into mind. Well-maintained walkways and the provision of crossing controllers on the routes can raise the level of accessibility and connectivity. Walkability can be promoted through planning and designing the built environment in ways that encourage pedestrians. Walkability can be accomplished through developing a setting that facilitates pedestrians to lessen their dependency on automobiles, reduce environmental pollution, promote a sense of community, and increase their level of physical activity.
3. 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. Finally, based on the findings, for streets to be successful, they should adopt a range of services that play a role in attracting people.

Appendix 1

Questionnaire survey form

Questionnaire survey form

Study area :

No. of form:

Please for question in sections 1, 2 bellow tick on the suitable choice:

Please select one of the five choices below for section A

Score Ranking Description

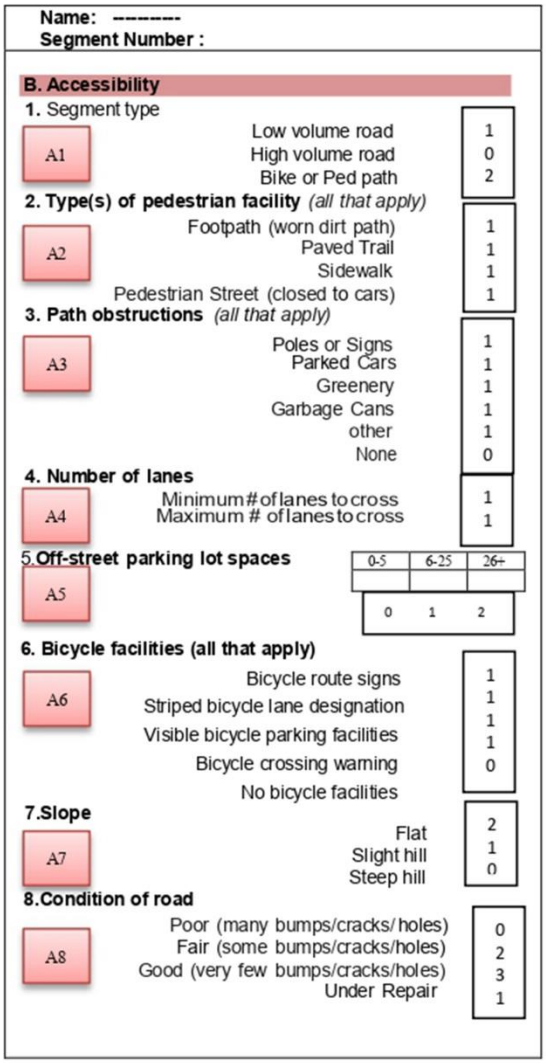
Strongly Disagree(SD)	Disagree(D)	Neutral(N)	Agree(A)	Strongly Agree(SA)
1	2	3	4	5

A. Streets linked to the squares

No	A-Accessibility	1	2	3	4	5
1	It is easy to use this street, pathway, and sidewalk because they are labeled by signs.					
2	Public transport stations are close enough to reach by foot from this street.					
3	Traffic lightings are quite regulated in this street.					
4	Traffic flows slowly in the street .					
5	This street, pathway, and sidewalks are free of obstacles.					
6	It is possible to reach this street by using several means of travel, such as foot, cycling, or public transit.					
No	**B-(Connectivity)**	**1**	**2**	**3**	**4**	**5**
1	This street has a good connection and there are few intersections.					
2	The availability of the signs and way-finding features here is very helpful to connect with nearby destinations.					
3	There is a good connection between this street and the public transportation station.					

Appendix 2

PEDS checklist form for streets



Appendix 3

PEDS checklist results for streets

Study area		A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	Total
Streets linked to the Nishtiman square	N.S.(A)	1	1	3	1	0	0	2	3	0	0	1	1	0	13
	N.S.(B)	1	1	0	1	0	0	2	3	5	0	1	1	0	15
	N.S.C(C)	1	1	1	1	0	0	2	2	3	0	1	1	0	13
	N.S.(D)	2	1	2	-	-	-	2	-	-	-	-	-	5	12
Total		5	4	6	3	0	0	8	8	8	0	3	3	5	53
Average		1.2	1	1.5	0.7	0	0	2	2	2	0	0.7	0.7	1.2	13.2
Streets linked to the Kotri Salam square	K.S.S.(A)	1	1	1	1	0	0	2	2	5	0	1	1	0	15
	K.S.S(B)	1	1	1	1	0	0	2	3	4	0	1	1	0	15
	K.S.S(C)	1	1	1	1	0	0	2	2	4	0	1	1	0	14
Total		3	3	3	3	0	0	6	7	13	0	3	3	0	44
Average		1	1	1	1	0	0	2	2.3	4.3	0	1	1	0	14.6
Streets linked to the Governorate Salam square	G.S.(A)	1	1	1	1	1	0	2	3	5	0	1	1	0	17
	G.S.(B)	1	1	2	1	1	0	2	2	5	0	1	1	1	18
Total		2	2	3	2	2	0	4	5	10	0	2	2	1	35
Average		1	1	1.5	1	1	0	2	2.5	5	0	1	1	0.5	17.5

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

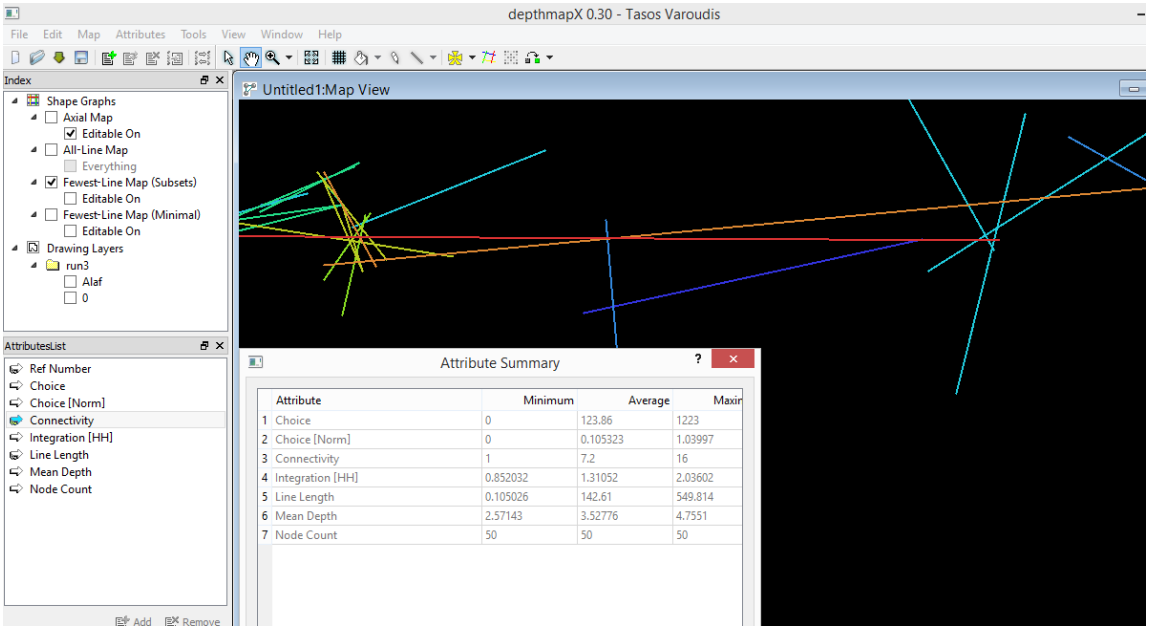
K.S.S(C). Street **C** linked to Kotri Salam square;G.S.(A). Street **A** linked to Governorate square; G.S.(B). Street **B** linked to Governorate square

A. Accessibility: A1. Segment type ; A2. Type(s) of pedestrian facility ; A3. Path obstructions ; A4. Number of lanes
A5. Off-street parking lot spaces; A6. Bicycle facilities; A7. Slope; A8.Condition of road
A9. Segment Intersections; A10. Curb cuts; A11. Sidewalk completeness/continuity;A12. Sidewalk connectivity to other sidewalks/crosswalks

A13.Bus stops.

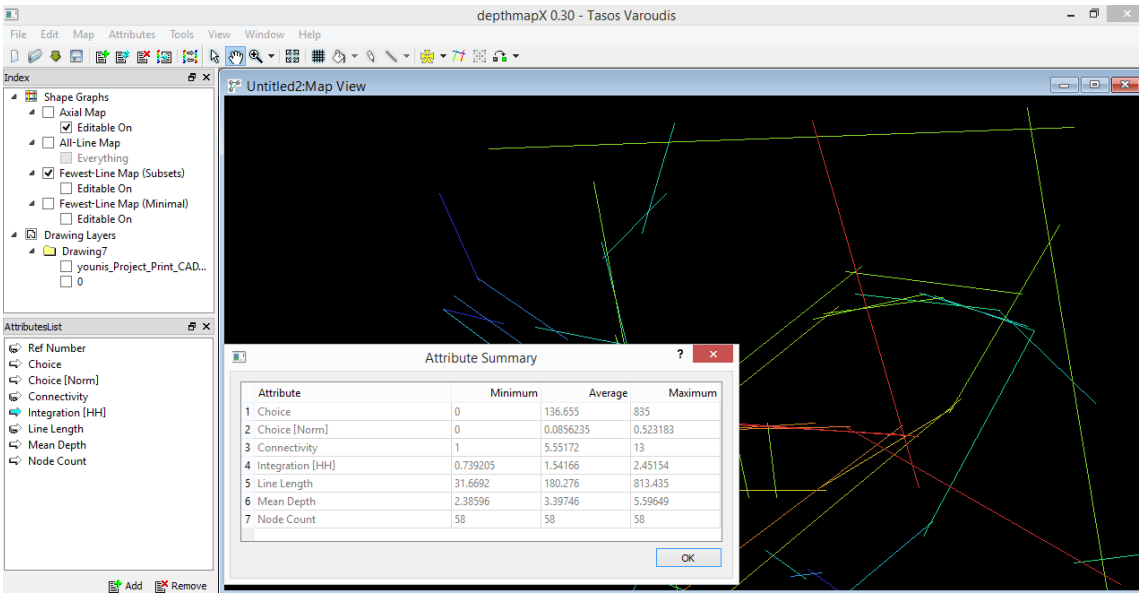
Appendix 4

Analysis of connectivity for the streets linked to Nishtiman Square prepared by the researcher



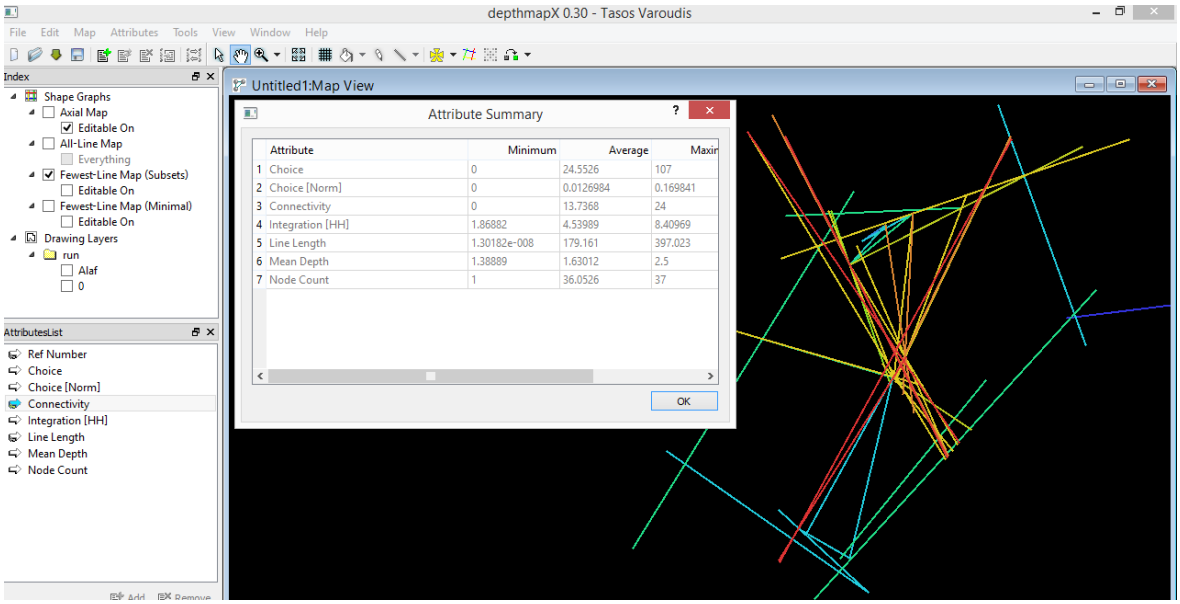
Appendix 5

Analysis of connectivity for the streets linked to Kotri salam Square prepared by the researcher



Appendix 6

Analysis of connectivity for the streets linked to Governorate Square prepared by the researcher



Appendix 7

Modified a part of PEDS checklist

PEDS checklist variables	Factors affects walkability (based on literature review)	Categorization a part of PEDS variables according to different references
Path obstruction ,bicycle facilities, Number of lanes, Power lines along segment, path condition/maintenance, slope, Segment type, uses in segment, Bus stops, condition of road	Accessibility	Path obstruction, condition/maintenance, condition of road (Abdullah, 2019),(Southworth, 2005). bicycle facilities, Number of lanes, Power lines along segment(Livi ,2004),). On-street parking(Radha et al,2020), path slope, (Cauwenberg et al.,2012)(Winslow,2013) Segment type, uses in segment (Livi ,2004) , Bus stops.

Appendix 8

Results of observation

The total average observation results of the studied streets (four different seasons from October 2021 to January 2022)			
Observation elements	**The streets linked to Nishtiman square**	**The streets linked to Kotri Salam square**	**The streets linked to Governorate square**
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

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