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Assessment of Pedestrian Walking Characteristics at Erbil CBD

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Abstract

To enable and encourage walking, understanding of the characteristics of pedestrian movements is vital. The restrictions on vehicular movement, and scarcity of parking lots had changed the whole traffic movement to the unserviceable condition. Therefore, walking is considered as the most efficient mode of transportation at Erbil CBD area. In developing countries like Iraq, however, the recognition of the importance of pedestrian walking studies is still infancy; the published data is scarce on this important mode of travel. The knowledge of pedestrian characteristics could effectively assist in the optimization of policies concerning urban land use and the locational distribution of pedestrian facilities in Erbil. In this paper, the pedestrians and their walking characteristics in two specific locations at Erbil CBD were studied. The continuous video capturing technique was implemented, the variations in walking speed of pedestrians among pedestrian characteristics such as gender, age group, and clothing traditions have been detected. The level of service was calculated for each sidewalk location. It has been found that the local pedestrians walk slower than other pedestrians in the developed countries or in the region. The mean free flow walking speed of Erbil pedestrians that has been observed is 51.31 m/min and is comparatively slower than that of others countries. On contrary, elder Pedestrians (50 years or older) were the slowest among others, with an average walking speed of nearly 20 m/min. The walking speed, pedestrian density, and flow rate of pedestrian were modeled. Mathematical models were obtained and compared with those of other countries. It was concluded that male pedestrian wearing Kurdish style are faster by about 2 m/min when compared to pedestrian wearing western style (trousers). When female pedestrian are considered, the variation of walking speed among using different clothing style was not significant. Knowing the local pedestrian characteristics and its variation from the international standards is essential in the design of pedestrian facilities.

Keywords: *pedestrian, walking behavior, clothing tradition, walking speed*

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INTRODUCTION

Pedestrian facilities are an integral part of the overall transportation network. Pedestrianization has become an integral part of sustainable modern urban design. The design, arrangement and development of transportation infrastructures should serve pedestrian movements to popularize walking. To achieve this, pedestrian facilities planning should be based on information on road user characteristics, travelling patterns and objectives of pedestrians flow. The implementation of a plan without pedestrian studies might lead to a very costly trial and error due to the implementation cost[1]. Hoogendoorm *et al.*[2] stated that two people walking side by side or passing each other while travelling in opposite directions take up an average space of 1.4 m with adequate buffer areas on either side as demonstrated in Figure 1. The minimum width that best

serves two pedestrians walking together or passing each other is 1.8 m. For design purposes, the HCM[3] sets out a simplified body ellipse of 50 × 60 cm for standing areas, with a total area of 0.3 m^2 as shown in Figure 2.

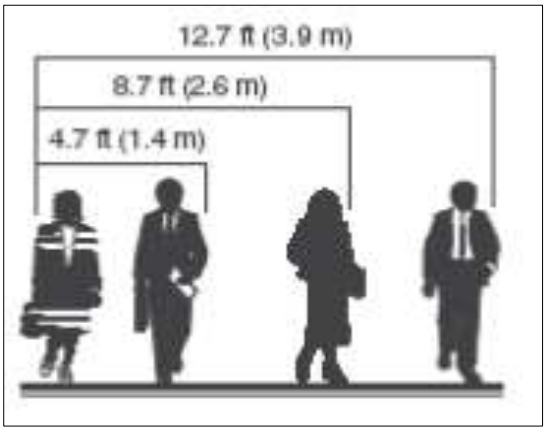

Fig. 1: *Spatial Dimensions for Pedestrians. (Hoogendoorn et al., 2007).*

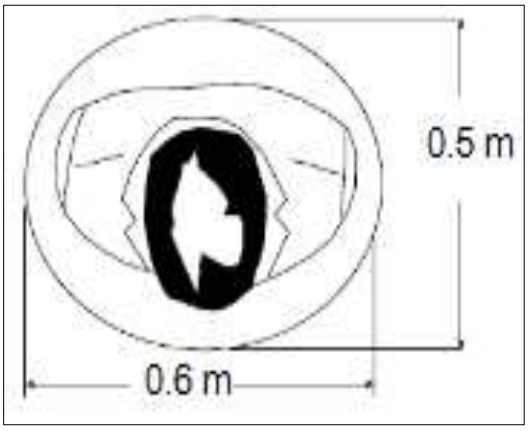

Fig. 2: *Pedestrian Body Ellipse for Standing Areas, (HCM, 2000).*

When determining pedestrian density, location and size of measurement area shall be carefully selected. Hoogendoorm *et al.*[2] demonstrated that high density of pedestrian can occur very locally such as waiting in front of stairs. The average measured density therefore depends directly on how the measurement area is defined[4,5].

Sarsam[6] stated that the factors which contribute in walking speed of male and female pedestrian are clothing tradition, gender, and age group. He also noticed that male pedestrians move faster than female pedestrians. Pedestrians in the age group of 15–30 years had the highest speed range i.e., 77.7–66 m/min, on the contrary, female pedestrian had range of 74.5–69.9 m/min. for the same age group.

It is also stated in literature that different land use locations have different effects on pedestrian movements. For example, Al-Masaeid *et al.*[7] developed pedestrian speed-flow relationships for CBD areas in developing countries and compared them to the average values quoted in the HCM. One of the earliest researchers of pedestrian behavior was developed by Poulos[8] who used slow motion video surveys to collect pedestrian data. Since then, the method has been widely used and described including[9;10,11]. The aim of present study is to scrutinize how urban characteristics and land use can affect pedestrian mobility, in terms of their walking and crossing speed and to model the effect of pedestrian characteristics such as clothing tradition, age group, and gender on walking speed.

SITE DESCRIPTION

The case study was performed in the CBD area at the city of Erbil. The speed, density and volume determinations were conducted. Two sidewalks along the main streets were selected as the observation sites for each location. The pedestrian volume and speed data were collected at two selected locations in Erbil; the first being Al-Qalat is located in a tourist zone; while the second site (Ainkawa) is located in a recreational and shopping zone as depicted in Figure 1. It was expected that sites with different land use could show different pedestrian characteristics.

COUNTS METHOD

Collection of Geometric Data

The required data of each survey site in Erbil are recorded. The effective width of

sidewalks was recorded and measured for each survey site. Video recording was performed; the video provided more details that could be observed in a repetitive manner and with awareness. The video camera used was a Canon HG10 and the sampling period was for 1 hour. The studied segment of sidewalks has dimensions shown in Table 1; where the arcades widths are measured as the available space for pedestrian to walk.

Sampling

The collection of the field data was made for sample lengths of 1 hour and during good weather conditions i.e., a sunny or cloudy day without rain. It was similar to the previous work conducted on Baghdad city by the authors[12]. The hours in which the counts were performed, were the ones where the peak hour was expected to take place. It must be stated that some counts were performed for more than an hour e.g., 2 hours. The hours selected considering the background information of the place were in the range 13:00–14:00 and 17:00–18:00. The main sample days used was workdays. In this respect, random days among this group were chosen from December, 2013 and April 2014. The data gathered includes the walking time and approximate age; that was based on a subjective judgment. Young were considered to be below 18 years, adults between 18 and 50 years and the rest as elderly. The clothing tradition was Kurdish male and female styles as shown in Figure 2.

Table 1: *Dimension of Sidewalk Test Section for Each Street.*

Street location	Length of section (m)	Width of section (m)
Al-Qalat	8	1.5
Ainkawa	8	2

Fig. 1: *Al-Qalat and Einkawa Street in Erbil City.*

Fig. 2: *Typical Kurdish Clothing Style Google Earth (2014).*

Pedestrian Walking Speed, Volume and Density Determination

The technique adopted in the field work is by marking a longitudinal section of known length and width on the pedestrian facility and continuously recording the movement of pedestrians within this section using video capture. Pedestrians were manually timed over a measured test; length, volume and speeds were then calculated. Random pedestrian about to enter the section was selected and tracked through the study area. The time taken by a pedestrian to traverse the test length was

measured using a digital stop watch, the entry and exit times in and out of the test area were recorded. Walking speed is then calculated by dividing the known length of the section by the walking time. The density was obtained by counting the number of walking pedestrians within the boundaries of the observation section site at a unit time.

The flow was recovered by counting the number of pedestrians passing the section entry and exit lines of the observation site within the given time interval. Data was subjected to statistical analysis using SPSS Statistics V.19 software. The volume, speed, and density were calculated using the mathematical models depicted below[13]. Using this information, regression models have been constructed and the predictive performances of these models were assessed. The data obtained from the field survey were examined to determine the relationships between speed and flow, speed and density, and flow and density.

$$S_N = L / T_N \quad \text{Eq. (1)}$$
$$S_S = L / T_S \quad \text{Eq. (2)}$$
$$D = V / S \quad \text{Eq. (3)}$$
$$V_u = V / W_e \quad \text{Eq. (4)}$$
$$D_u = V_u / S \quad \text{Eq. (5)}$$

Where T_N; T_S represents travel time in each direction (min)
S_N; S_S represents the space mean speed (meter / minutes) in each direction
L = the test section length (meters)
D = the density of pedestrian (pedestrian / meters)
V = the volume of pedestrian (pedestrian / 15 minutes)
W_e = Effective width of side walk section in meters
S = pedestrian speed (meters / minutes)
V_u= unite width flow (pedestrian / 15 minutes / meter)
D_u = the unit area density of pedestrian (pedestrian / meters^2)

ANALYSIS AND DISCUSSION OF FIELD DATA

Variation of Walking Speed with Gender and Land Use

Table 2 represents pedestrian mean and 15th percentile speeds in relation to pedestrian gender for Erbil. The 15th percentile speed is the one normally used in design and it means that 85% of pedestrians walk faster than this speed. As indicated in the Table, male pedestrian walk faster than female for both of the tested sites. Such findings agrees with the study held in Singapore by[14] which shows that the Singapore males generally walked faster than the females as their mean walking speeds are 79 m/min and 69 m/min for males and females respectively. The present study shows lower walking speed in general as compared to walking speeds[5] for Saudi Arabia (mean walking speed 65 m/min) and for Indonesia (mean walking speed 52 m/min).

On Erbil site, a tourist zone, shows the slowest walking speed (mean walking speed is 20.1–18.2 m/min. for male and female respectively). This could be related to the presence of older age pedestrians. The shopping and recreational site exhibits almost slower walking speed of a range 20.6–30.7 m/min. for both genders. Figure 3 depicts the minimum, maximum, and the mean walking speed for male and female for Erbil. This slow speed may be attributed to the fact that people were not in hurry and move slowly to enjoy the shopping site. This was in agreement with work done by Lam *et al.*[15] as cited by Sarsam *et al.*[16] who observed that pedestrians walking in commercial areas are faster than those in recreational areas, and the walking speed of the pedestrian depends on the surrounding environment. The wide range of variation of mean speed between the tested sites which reflects the impact of land use was in agreement with previous researches[17] in their statement that pedestrian walking speeds varied from

98–33 m/min and with other researchers[1,6] in their study for Mosul and Baghdad . Rastogi *et al.*[19] tabulated a global walking speed of a range 65–90 m/min in their study as cited[12].

Table 2: *Pedestrian Speed in Relation To Gender for Erbil City.*

Tested site	Pedestrian walking speed (m/min.)		
	Gender	Mean	15th percentile
Site 1 (Al-Qalat)	Male	25.8	18.2
	Female	20.6	16.5
Site 2 (Ainkawa)	Male	20.1	14.1
	Female	18.2	14.9

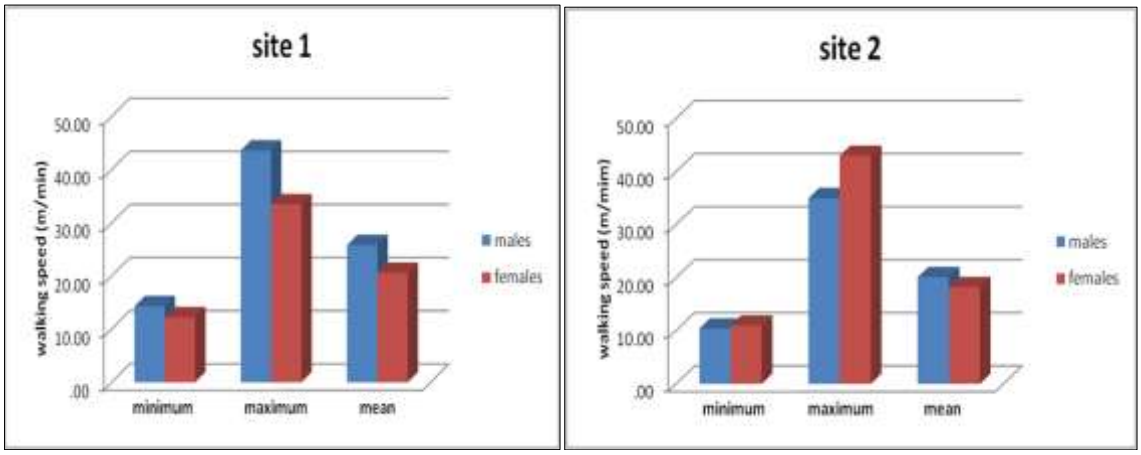

Fig 3: *Variation of Walking Speed with Gender.*

Effect of Age Groups on Walking Speed

As indicated in Figure 6, adult pedestrians (18–50 years) were the fastest compared to other age groups with an average speed of 30.9 m/min and 24.3 m/min for male and female respectively at Erbil site 1. Pedestrians 50 years or older (elderly) were the slowest among others, with an average walking speed of nearly 20 m/min. These findings are in agreement with those reported[1,5,6,8,18,20]. Figure 4 shows the variation of walking speed with gender and age groups for Erbil.

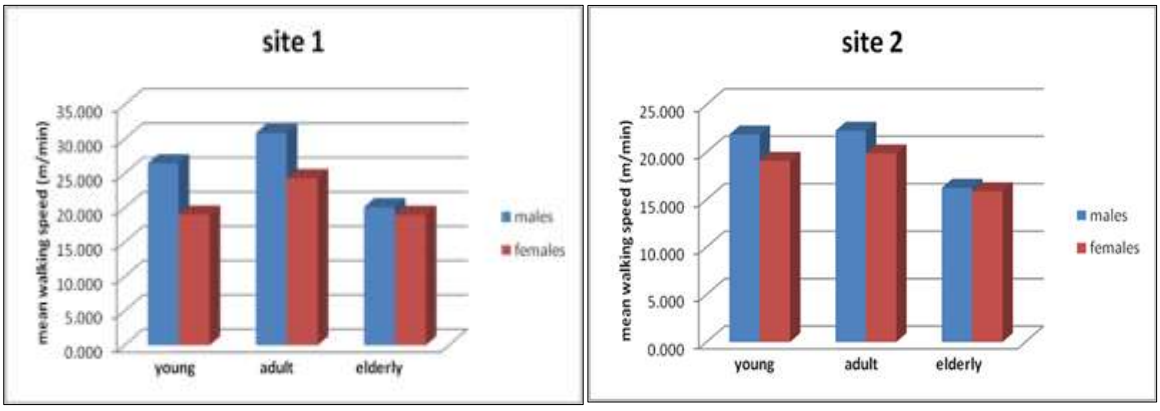

Fig 4: *Variation of Walking Speed with Gender and Age Groups.*

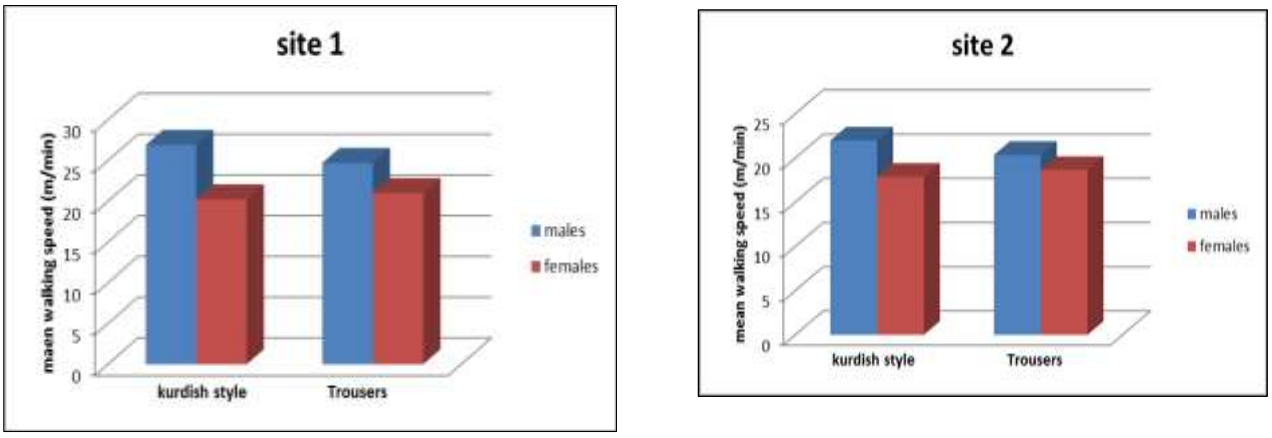

Fig 5: *Variation of Walking Speed with Gender and Clothing Tradition.*

Effect of Clothing Tradition on Walking Speed

Figure 5 illustrates bar charts for the variation of mean walking speed of pedestrian in relation to pedestrian clothing tradition for Erbil city and it shows two clothing traditions: Kurdish style and western style (trousers) for both genders. It was found that males wearing Kurdish style are faster by about 2 m/min when compared with pedestrian wearing trousers.

This was in agreement with Sarsam[6] findings on the effect of local clothing tradition, where it was found that males wearing trousers are faster than males wearing Arabic style by about 3.9 m/min. This may be attributed to the limitations practiced in the step length, which is restricted due to clothing when using the western clothing tradition. When female pedestrian are considered, the variation of walking speed among using different clothing style was not significant.

This could be attributed to the slower average speed of female as compared to male. This was found to be in agreement results found by Kuishki *et al.*[5] in Saudi Arabia and Sarsam[6] in Baghdad.

Pedestrian Traffic Flow Characteristics

Table 3 shows the variation of pedestrian flow rate and walking speed among different sites in Erbil. The mean flow rate of 96 pedestrian per 15 minutes per m is considered high when compared to other studies in Europe and United States[14] while it is comparable to the other findings[6,17].

Table 4 shows the level of service for each site. Figure 6 below represents the (walking speed-Pedestrian density) relationship for Erbil. The mean free flow walking speed was found to be 51.31 m/min.

The mean free flow walking speed of Erbil pedestrians was observed to be comparatively slower than that of American counterpart with 88 m/min[4]. Table 5 shows a comparative summary for the designing of mathematical models.

Table 6 shows comparison of pedestrian walking speeds in different studies. On the other hand, Figures 6, 7, and 8 demonstrates the green shield models obtained.

Table 3: *Characteristics of Pedestrian Traffic Flow.*

site	Unit width Flow rate (Ped/min/m)	Mean walking Speed (m/min)	Standard deviation	Density (Ped /m2)
Site 1	49	26.627	6.23	1.88
Site 2	45	21.617	5.39	2.08

Table 4: *Level of Service Parameters.*

site	Effective walking area (m2)	capacity (Pedestrian)	V/C ratio	LOS
site 1	12	37.6	0.86	E
site 2	12	41.6	0.72	E

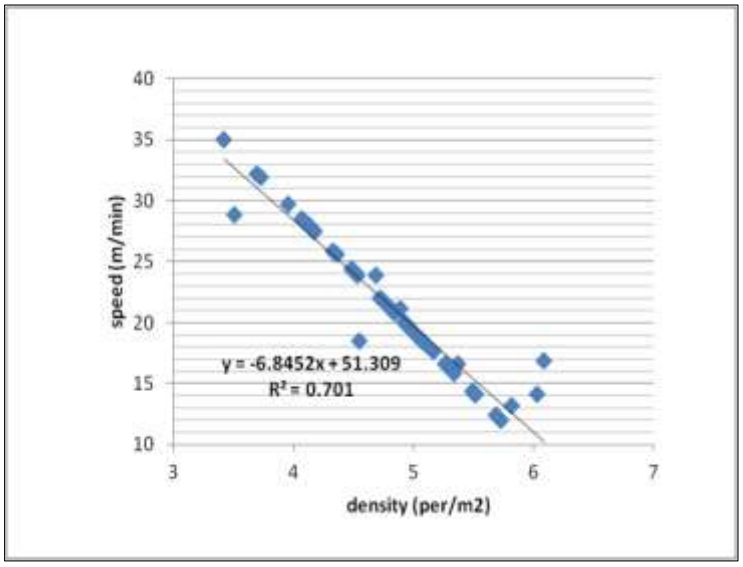

Fig. 6*: Density-Walking Speed Relationship.*

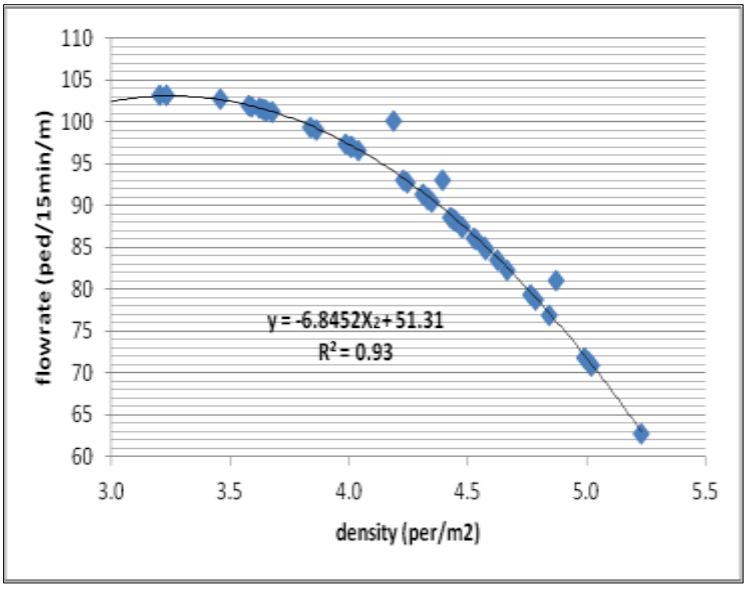

Fig. 7*: Flow Rate-Density Relationship.*

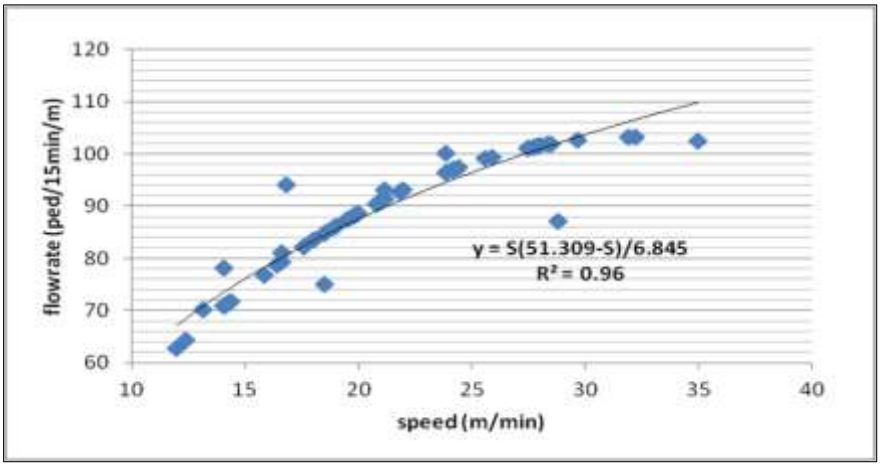

***Fig. 8**: Flow Rate-Walking Speed Relationship.*

***Table 5**: A Comparative Summary for the Design Mathematical Models.*

City, Country	S = f(k)	Q = f(k)	Q = f(S)
USA	S = 81.4–20.4k	Q = 81.4k–20.4k²	Q = S (81.4–S)/20.4
Britain	S = 78.6–20.2k	Q = 78.6k–20.2k²	Q = S (78.6–S)/20.2
Singapore	S = 73.9–15.3k	Q = 73.9K–15.3k²	Q = S (73.9–S)/15.3
Mosul	S = 2.5–0.04k	Q = 2.5K–0.04k²	Q = S (2.5–S)/0.04
Baghdad	S = 63.586–9.93k	Q = 63.58k–9.93k^2	Q = S(63.58–S)/9.93
Erbil (present study)	S = 51.309–6.84k	Q = 51.31k–6.84k^2	Q = S(51.31–S)/6.84

***Table 6:** Comparison of Pedestrian Walking Speeds in Different Studies (Sarsam and Abdulameer, 2015).*

City, Country	Free flow Speed (m/min)	Author(s)
American and European Countries		
Pittsburgh, United States	88.0	Hoel (1968)
London, England	79.0	Older (1968)
Columbia, United States	79.0	Navin and Wheeler (1969)
New York, United States	81.0	Fruin (1971)
Paris, France	87.6	Kamino (1980)
Asian Countries		
Fukuoka, Japan	81.0	Kamino (1980)
Koori-cho, Fukushima, Japan	69.6	Kamino (1980)
Osaka, Japan	90.0	Kamino (1980)
Tokyo, Japan	93.6	Kamino (1980)
Roorkee, India	84.0	Laxman *et al*. (2010)
Madras, India	72.0	Victor (1989)
Singapore	74.0	Tanaboriboon *et al.* (1986)
Riyadh, Saudi Arabia	65.0	Koushki (1988)
Yogyakarta, Indonesia	52.0	Poei *et al.* (1995)
Kuwait city, Kuwait	71.0	Koushki and Ali (1993)
Shanghai, China	72.0	Yu (1993)
Mosul, Iraq	29.6	Sarsam (2002)
Baghdad, Iraq	63.5	Sarsam and Abdulameer (2013)
Baghdad, Iraq	66–74	Sarsam (2013)
Erbil, Iraq	51.3	Present study (2015)

CONCLUSIONS

Within the limitations of field investigation procedure and assumptions, the following conclusions may be drawn:

1. Male pedestrians have significantly faster walking speeds than female pedestrians by about 5% with mean walking speed of 25.8 m/min for Erbil.
2. Pedestrians of 18–50 years old are the fastest group of pedestrians with an average speed of 30.9 m/min at Erbil. Pedestrians over 50 years old were found to be the slowest group with an average walking speed of nearly 20 m/min.
3. Males wearing Kurdish style are faster by about 2 m/min when compared with pedestrian wearing western style (trousers) in Erbil city.
4. The mean free flow walking speed of Erbil pedestrians that has been observed is comparatively slower than that of others countries. In addition, it was found to be 51.3 m/min for Erbil.

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