The Impact of University Campus Spatial Organisation on Pedestrian Speed: A Comparison between the Old and New Campuses of Sulaimani University

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Abstract. Walkable university campuses require comprehensive planning and design that considers the campus as a whole, which means that buildings and the surrounding environment should not be segmented from a walkability point of view. Without considering the walkability criterion, the spatial organisation of the teaching buildings on university campuses may negatively impact pedestrian speed. This paper outline a comparative study of the old and new campuses of Sulaimani University, which have different types of spatial organisation, to demonstrate the impact of campus layout design on pedestrian speed. The aim is to show how university campus design and spatial organisation type affect pedestrian speed and determine the best type of campus layout design from a walkability point of view. For the empirical study, data were collected through video recordings and observing pedestrian speed between 8:00 am and 9:00 am for 15 days on both campuses. The recorded data were then transformed into numerical values such as speed, and different types of walking. In a second step, data about physical characteristics of campuses design were collected, such as walkway length, width and level, and number of pedestrian walkway intersections. Finally, using multiple linear regression analysis, a mathematical model was designed to test campus spatial organisation on pedestrian speed. In this way, comparing the results for the campuses, the findings reveal that campus layout design and walkway characteristics affect pedestrian speed with different impact ratios. The results indicate the best spatial organisation type for walkable campuses.

Keywords: walkability, pedestrian speed, spatial arrangement, university campus

1 Introduction

The number of students on university campuses is continuously increasing, which requires careful attention to long-term planning and design. Contemporary design, including sustainable design, encourages the implementation of walkable transportation into the planning and design of university campuses to maximize user's health and economic satisfaction and to reduce pollution and expenses on campuses. Designing and implementing a pedestrian transportation system into campus planning and design can provide several advantages, such as minimizing the amount of land used, reducing vehicle reliance, reducing resource consumption and pollution, encouraging walking, increasing accessibility to facilities and service areas, ensuring more efficient provision of infrastructure and utilities, and re-developing areas [1]. Therefore, it is of particular concern for urban planners, designers, developers, investors, and others interested in walkability to invest in the walkability of a property because of the social, economic, health, and environmental benefits [2]. Several characteristics of walkable communities are frequently described in research. This paper studies pedestrian speed and the impact of the spatial arrangement of teaching buildings (i.e., the impact of the design type on pedestrian speed) from a walkability perspective.

Walking is a common form of physical activity and has many social, health, and recreational benefits [3]. It is the most sustainable type of transport and the one that has the least impact on the environment [4, 5]. In addition to trips where walking is the main mode of transportation, walking comprises at least a portion of all other trips because people become pedestrians when they get out of vehicles or dismount from other modes of transportation [37]. Despite its effective role in providing urban mobility, there has been a decline in walking in the past. However, there appears to be a slight reversal to this trend in the last few years. However, fewer people now walk to work, school, university, or shops than in the past, and increasing obesity levels are part of a wider trend towards decreasing activity levels for parts of the population at all ages. When urban planners and designers neglect pedestrians as a main component of the transportation system, the resulting systems are suboptimal from the perspective of walkability, sustainability, and multi-modal transportation efficiency and equity [6]. Transportation systems that are designed only for motorized traffic also impose dangers on those who walk [7]. Rapid motorization, inadequate traffic enforcement, and unwalkable built environments contribute to majority of global road traffic injuries, which are now a leading cause of death and disability at a global scale [34]. According to a recent study, urban pedestrians are the primary victims of this growing public health epidemic—representing between 55% and 70% of road traffic deaths in the developing world [8].

Generally, in any urban environment there are two types of walking. The first type of walking is a means of getting to a destination, and this is the type that is most critical to human beings' everyday traveling needs. The most obvious instance of this type of walking is daily walking between home and work or within business or other active zones such as university campuses, schools, and shopping malls [38]. The second type of walking is a form of leisure [9]. People obtain utility from this type of walking, and it can range from fast walking for exercise to relaxing walking one within a park or other recreation area [9, 38]. The design of such walking facilities is no longer from a transportation standpoint where efficiency matters most. Instead, considerations for pedestrians' sight, sound, smell, and touch need to be encouraged in the design so that pedestrians have an enjoyable walking experience [10]. These two types of walking can be differentiated as "necessary" and "optional" types of walking [23].

Abley (2011) defines walkability as "*…the extent to which walking is readily available as a safe, connected, accessible and pleasant mode of transport*". [32]. Walkability can also be defined as a measure that identifies the perceived friendliness, aesthetics and safety of an urban environment [35]. Southworth [11] defines walkability as the extent to which the built environment supports and encourages walking by providing for pedestrian comfort and safety, connecting people with varied destinations within a reasonable amount of time and effort and offering visual interest in journeys throughout the network. Walkability is an effective factor in having a sustainable transportation system and can be used to assess the friendliness of an area, many subjective factors considered in the process [35]. Walkable areas increase walkability and, consequently, sustainable transportation, which is a concept that encourages transportation systems that have a low impact on environment as well as increasing the physical health and safety of a community [12, 13, 35]. In summary, walking is a common form of physical activity and has both social and recreational benefits. It is studied as a way of achieving sustainability from a social activity point of view. Further, walkability is the degree to which an area is within walking distance of a property at an average speed rate and encourages walking for functional or recreational purposes.

2 Walking Speed

Walking speed is the speed at which a pedestrian walks in undisturbed circumstances. Pedestrians walk at different paces, with people walking at a speed that they find most comfortable. The speed can be identified in a normal situation, for hurried pedestrians at a transportation station, and for leisurely shoppers in shopping environment. According O'Connor and Donelan [14] the standard walking speed for pedestrian is about 1.33 m/s. There are several factors that influence a pedestrian's normal walking speed. According to Azmi and Karim [15], the average walking speed of males is higher than the average walking speed of females. On average, women walk 3 miles (4.8 km) per hour, which is 20 minutes per mile, while men walk a slightly faster 3.5 miles (5.6 km) per hour, which is 18 minutes per mile [15]. According to Utermann [24] the main factors that can affect walking speed include:

1. Walking at crossing intersections is usually slower than normal walking.
2. Pedestrian density is inversely related to pedestrian speed. As density increases, speed decreases.
3. Stairs and steps act as barriers and can reduce walking speed to about 1/3 the speed of level conditions and constrict traffic flows.
4. Other factors can slow down the average walking speed, such as age, sex, health, and condition of the walker.

3 University Campus

The term university campus refers to an institutional space that is designed for the education and residence of college students and includes the service buildings and other physical elements found in the associated area. The establishment of a university campus usually occurs in stages according to current needs for growth and development. Further, existing university campuses require further development from time to time, based on objectives that must be achieved. The physical development and planning of a campus can be considered successful if the project goals are achieved [16].

A campus can also be considered a city consisting of elements that are highly interdependent. According to Dober [25], there are three main parts of a campus, namely buildings, outdoor spaces, and support elements such as utilities and circulation systems. Regarding the typology of university structure, there are three basic types of universities illustrated in UK practice [26]:

1. Oxbridge: Consists of a number of semi-autonomous colleges providing residential and catering facilities for students and staff together with some small-scale teaching spaces, with some central shared facilities jointly administered. This type is unique to Oxford and Cambridge.
2. London: Consists of a number of almost independent colleges, many of a specialist nature, with each a virtually self-contained university. There are some central services, with nearly all duplicating college facilities. This type is unique to London.
3. Provincial: Consists of a number of subject departments or faculties as well as various central facilities, usually including an element of residential accommodation. This is the archetype, and most of what follows applies to this type of university.

The provincial type of university can be built in one of two ways or a combination of them [26]:

- Integrated and dispersed, where separate buildings and facilities are found among the local community as and where sites become available. Facilities are often fitted into converted existing buildings, with space standards possibly modified. Otherwise, the design principles are not different from the campus type.
- Campus, where all or most of the buildings are arranged on one large site.

Universities with large numbers of academic staff members, students, and administrative personnel and a variety of activities (e.g., working, studying, business) are comparable to small cities. Accordingly, walkability on such a university campus is important to help users have a healthy and social lifestyle [17]. Universities should encourage people to shift their travel mode from cars to other types of travel, especially walking. Thus, walkability is considered a foundation for designing a walkable and sustainable campus [18]. From the view of physical development planning, a wide and disperse plan contrasts with the concept of a walkable campus, as it increases the distance between areas, increases reliance on vehicles, increases air pollution, creates accessibility problems, constricts infrastructure and facilities management, reduces energy efficiency, and creates a poor social life in addition to minimizing walkability [33].

Studies have proposed several dependable planning types for the design of university campuses. Adler [26] suggested three common campus types that are the best for designing and developing existing university campuses: molecular type, linear type, and radial type. Edwards (2001) stated that it is possible to distinguish nine types of campus plans among the countless universities across the world. Any classification is, however, frequently compromised by the passage of time [27]. A university starts with one type of organising principle, which rarely survives the change of ambition of different leaders or the evolving values of successive generations. The different campus development paradigms are a means of achieving the efficient utilization of land and infrastructure while giving universities that rare but essential quality—academic character. Different layouts have been popular during certain periods of university development. According to Edwards (2001), the realm of campus planning is rarely made up of simple choices exercised by rational decision makers on the basis of quantifiable data. Edwards [27], identified nine types of master plans for university campus design: (1) place making (building dominated); (2) place making (landscape dominated); (3) collegiate type; (4) linear type; (5) grid type; (6) modular type; (7) molecular type; (8) radial type; and (9) ad hoc type.

For all campus type walking is an extremely important function that its circulation design must facilitate, as all transportation modes end in walking. Kenney et al. [28] described that the university campus should be pedestrian-oriented because walking is the healthiest transportation option and the most conducive to promoting an increased sense of community. As a general rule, a campus walking system should be direct, continuous, and free of conflicts with vehicles. While students interact with only select cases of campus architecture throughout the week as determined by their schedule, they interact with the outdoor landscaped campus by walking many times per day. Movement through campus offers the unique opportunity of crafting a pleasant, beautiful, safe, and memorable experience. While traveling through a campus by walking should first be efficient, the impact of a high-quality landscaped environment on one's senses should not be overlooked [29]. The creation of designated automobile-free zones within the university campus is another strategy to create modal separation and allows for a more human-scale and pedestrian-friendly environment. By creating a well-designed pedestrian campus core, the spatial experience of the campus will be enhanced and encourage longer walking trips [28].

4 Empirical Study

In 1968, the University of Sulaimani, the first governmental university in Iraq's Kurdistan region, was founded in the city of Sulaymaniyah [36]. The university has two campuses; the old campus, founded in 1968, is located in a central part of the city and has a compact and clustered master plan design, while the new campus, completed in 2012, is located on the outskirts of the city and has a linear-type master plan design. The two university campuses are used as a comparative case study with the aim of determining the impact of university design type (i.e., the spatial arrangement of teaching buildings) on pedestrian speed. Each campus has a different type of master plan and spatial arrangement of teaching buildings. The new campus is located on a 1.9 million m2 area that accommodated 18,500 students for the 2018- 2019 school year. The design of the new Sulaimani University campus is totally different from the design of the old campus. The new campus has an elliptical master plan type where teaching buildings and all other service buildings are distributed on a main linear street as shown in Figure 1. The campus has two gates used for both vehicular and pedestrian accesses. The main gate is located at the south of the campus on Rapareen Road, and the secondary gate is located at the west of the campus on Qlyasan Road. Pedestrian walkways start from both gates, continue along the main street on both ends, and then branch out through the entire campus to each building. Due to a large number of students for all teaching building that exceeds more than 16000 students and to limit the study, 60% of teaching buildings are selected for the empirical study. Therefore six teaching buildings among ten were selected to observe and calculate pedestrian speed while walking from an origin, which is either the main gate (G1) or the secondary gate (G2), to their destination, which are B1, B2, B3, B4, B5, or B6, as shown on the master plan in Figure 1.

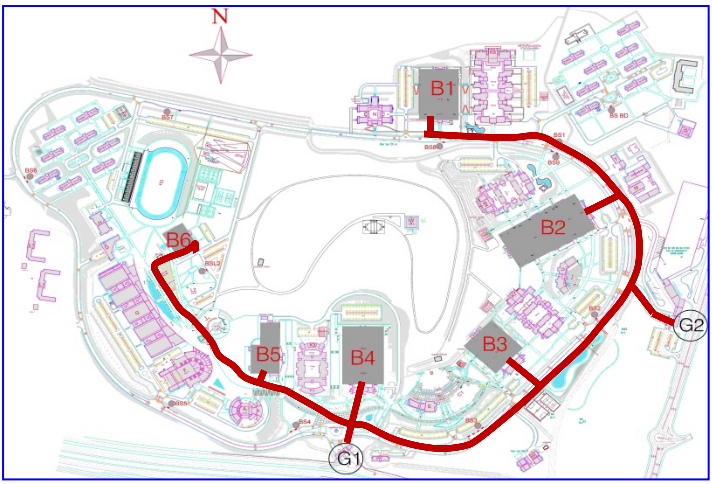

Fig. 1. Master plan of Sulaimani University new campus showing the selected teaching buildings arranged on a curvilinear street: B1; College of Language, B2; College of Science, B3; College of Basic Education, B4; College of Engineering, B5; College of Fine Arts, B6; College of Fine Arts, G1: Main Entrance, G2: Secondary Entrance), Source: (Directorate of Building Construction- Presidency of Sulaimani University)

Pedestrian speed was calculated by observing pedestrians' walking using video recordings then determining the speed per unit of length. Video was recorded between 8:00 am and 9:00 am, which is the peak hour of transportation inside the campus, for four days of the week (Saturday to Wednesday). Thursday was excluded from recording as some colleges do not have lessons on this day. After the data collection process was finished for the selected teaching buildings, data were analysed independently for the each building: (B1) College of Language; (B2) College of Science; (B3) College of Basic Education; (B4) College of Engineering; (B5) College of Fine Arts, and (B6) College of Sport.

The old campus of Sulaimani University it located on a 175,000 m2 area in the city centre and has a compact and cluster design master plan (i.e., a place making (building dominated) type), where teaching buildings are spatially organised around some public spaces, keeping an optimum distance between the buildings, as shown in Figure 2. For the empirical study, four teaching buildings were selected on the old campus to observe and calculate pedestrian speed while walking from the origin, which is the main gate (G1), to a destination (B7, B8, B9, and B10) as shown on the master plan in Figure 2. After selecting the teaching buildings (shown on the master plan), data were for each building: (B7) College of Medicine; (B8) College of Veterinary; (B9) College of Educational Science, and (B10) College of Pharmacy.

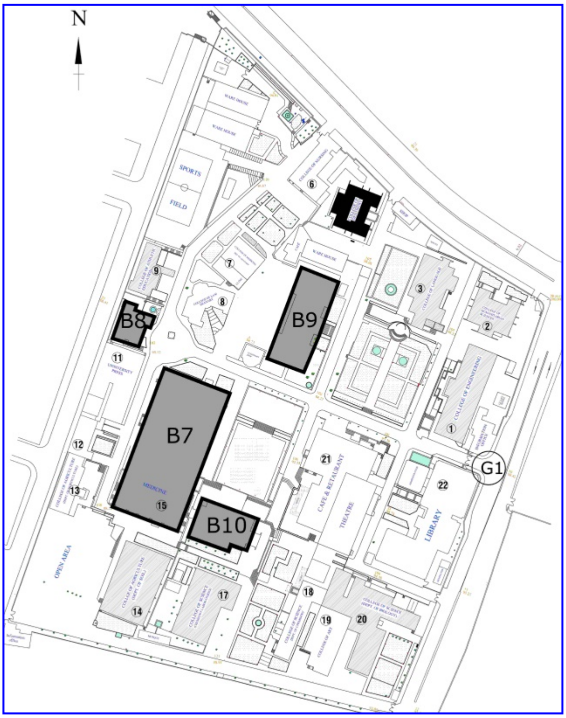

Fig. 2. Master plan of Sulaimani University old campus showing the selected teaching buildings: (B7: College of Medicine, B8: College of Veterinary, B9: College of Educational Science, B10: College of Pharmacy, G1: Main Entrance, G2: Secondary Entrance), Source (Directorate of Building Construction- Presidency of Sulaimani University)

5 Data Calculation and Results

The independent variables for the spatial distribution of teaching buildings in university campuses vary in terms of their degree of influence on pedestrian behaviour. Table 1 presents the variables related to the syntactic characteristic of the spatial arrangement for teaching buildings in the University campuses which are:

Table 1. The variables related to the syntactic characteristic of the spatial arrangement for teaching buildings in the University campuses.

Type of Variable	Variable		Symbol	Definition
Non-Physical (Dependent) Variables	Pedestrian Speed		**S**	Speed of pedestrians from the campus gates to the teaching buildings (m/s)
	Walking Type	No. of Pedestrians Walking in Group	**PG**	Pedestrians walking in a group on walkways
		No. of Pedestrians Walking Alone	**PA**	Pedestrians walking alone on walkways
Qualitative Physical (Independent) Variables	Walkway Length		**WL**	Length of a walkway from the campus gates to the teaching buildings
	Walkway Width		**WW**	Width of a walkway from the campus gates to the teaching buildings
	Level of the walkway (Height)		**WH**	Difference in height (level) of a walkway from the campus gates to the teaching buildings
	Intersections	Walkway with Walkway	**WIW**	The intersection of a walkway with another walkway
		Walkway with Street	**WIS**	The intersection of a walkway with a street
		Walkway with Open Space	**WIO**	The intersection of a walkway with an open space
Quantitative Physical Variables (Independent Variables)	Furniture Number		**FU**	The number of furniture items on a walkway to each building
	No. of Trees		**T**	The number of trees on a walkway to each building
	Walkway Finishing		**FI**	Existence of walkway finishing or concrete face

5.1 Pedestrian Speed (S):

Pedestrian speed is the speed at which pedestrians walk in an urban environment. Pedestrians walk at different speeds, but the standard average speed is 1.33 m/s [14]. Speed is a dependent variable and is considered a critical factor that affects pedestrian behaviour. Sometimes a pedestrian is in hurry or vice versa, which changes their behaviour. This variable is measured through direct observation of pedestrians walking on campus by video recording and then calculating the time pedestrians take to reach their destination. The average speed for each case is found using the following formula:

$$S = D / T \ . \qquad (\mathbf{1})$$

Since pedestrians' speed differs, mean speed must be found. For this purpose, the speed of 125 pedestrians was determined for each building. The mean speed was calculated with the following formula:

$$\bar{s} = (\sum s)/n\,. \qquad (2)$$

5.2 Walking type

Walking type is a pedestrian's behaviour while walking. There are two types of walking in any urban environment:

1. *Pedestrians Walking in a Group (PG):* This is the most common pedestrian behaviour and the most common walking type. Pedestrians walking in a group are mainly driven by self-organised processes based on local interactions among pedestrians. Most studies of pedestrian behaviour find that about 70% of pedestrians actually move in groups, such as friends, couples, or families walking together [18].
2. *Pedestrians Walking Alone (PA)*: This type of pedestrian behaviour occurs when pedestrians walk alone. Pedestrians walking alone have a faster speed than those walking in a group. Studies have shown that the majority of pedestrians do not walk alone but in groups [19, 20, 21].

These two variables are measured through direct observation of each sample within a specific time period using video recording and then calculating the number of pedestrians walking alone and the number walking in a group as shown in Figure 3.

Fig. 3. Sample of direct observation of pedestrian walking to teaching building (B1) calculating the number of pedestrian walking groups and walking alone.

5.3 Walkway length (WL)

A walkway is a continuous, unobstructed, and mostly raised passage or path for pedestrian circulation that provides accessibility and connects different sections in an urban environment [22, 31]. Walkways are the main paths pedestrians use for walking. The walkway length for the university campuses is the length of each walkway from the nearest gate of the campus to each teaching building measured in metre. The value of this variable is found for each teaching building on the campus master plan. Figure

4 shows a sample of the walkway length which pedestrians use to reach their destinations.

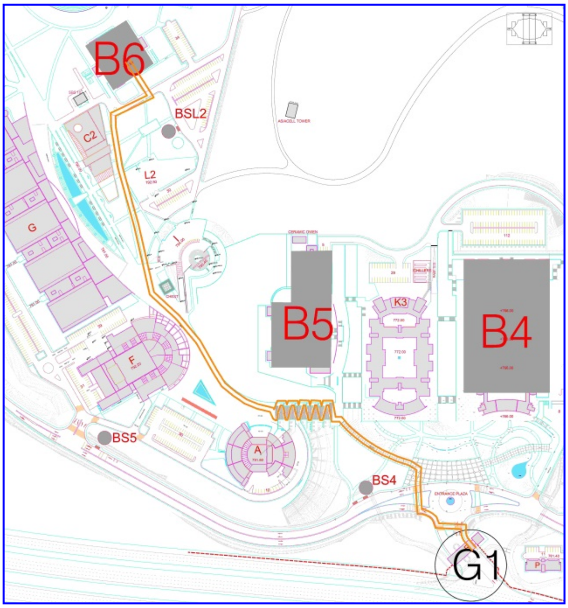

Fig. 4. A sample of the walkway length on campus master plan from gate main gate G1 to B6

5.4 Walkway width (WW)

Walkway width is another dimension of walkways measured in metre. The width of walkways on university campuses affects walkability. The width of walkways changes according to the usage of the walkway and the type of the environment [31]. The value of this variable is found for each teaching building on the campus master plan.

5.5 Walkway level (height) (WH)

The level or slope of a walkway is the difference in height between the starting and ending points. Walkway level is considered critical in the design of walkways for walkability, as pedestrians should feel comfortable while walking on walkways with a moderate level. According to the National Association of City Transportation Officials, a walkway's running slope should be no greater than 5% [30]. The value of this variable is found for each case on the campus master plan.

5.6 Intersections

An intersection is a point at which a walkway is cut for a specific purpose, after which it continues to the destination. Intersections of the walkways change pedestrians' walking behaviour according to their design [30]. In urban environments, there are transportation networks where walkways intersect with different elements, including the following:

1. Walkway Intersecting Walkway (WIW): This is the intersection of a walkway with any other walkway. This variable is measured by counting the number of walkways intersecting the main walkway.
2. Walkway Intersecting Street (WIS): This is the intersection of a walkway with streets on a university campus. This variable is measured by counting all streets that intersect the walkways on the campuses.
3. Walkway Intersecting Open space (WIO): This is the intersection of a walkway with an open space or a building's surrounding landscape. This variable is measured by counting the number of open spaces or building surroundings that intersect a walkway. Figure 5 shows different types of walkway intersections in university campus.

Fig. 5. A sample showing Walkway intersection with walkway (WIW), street (WIS) and open space (WIO), in the new campus of Sulaimani University

6 Discussion and Results

Data about pedestrian speed and other related variables were collected by observing pedestrians' walking using video recordings. All data were then converted to numerical values. Video was recorded from 3rd December 2017 to 21st January 2018 from 8:00 am to 9:00 am as this is the peak hour of pedestrian activity inside the campuses for net (15). After finishing the process of collecting data on pedestrian behaviour for each selected teaching building, the data for all selected teaching buildings on both campuses were analysed for difference in pedestrian speeds for both campuses. Tables 2 and 3 show calculated data related to physical variables for both pedestrians and campuses, such as walkway characteristics and number of intersections.

Table 2: Numerical values for five days samples from the fifteen days collecting data in the new campus of Sulaimani University campus

Selected Teaching Buildings	walkway length (WL)	walkway width (WW)	Walkway level (WH)	Walkway intersecting Walkway (WIW)	Walkway intersecting street (WIS)	Walkway intersecting space (WIO)	Furniture No.(Fu No.)	Tree No. (T. No.)	Walkway Finishing (FI)	Data Collection Days	Average Speed per day (S)	Ped. Group No. (PG. No.)	Ped. Alone No. (PA. No.)
B1	910	1	19.3	8	4	4	3	63	1	Day 1	1.2	235	205
										Day 2	1.22	217	210
										Day 3	1.2	227	208
										Day 4	1.2	244	215
										Day 5	1.19	237	214
B2	445	1	18.1	4	4	1	0	3	1	Day 1	1.27	271	289
										Day 2	1.28	237	354
										Day 3	1.27	254	273
										Day 4	1.27	268	311
										Day 5	1.27	264	281
B3	565	1	18.1	8	5	2	2	83	1	Day 1	1.26	194	204
										Day 2	1.27	172	201
										Day 3	1.28	205	186
										Day 4	1.23	191	214
										Day 5	1.25	173	208
B4	212	1	5	4	2	2	4	125	1	Day 1	1.31	213	264
										Day 2	1.3	211	317
										Day 3	1.32	192	297
										Day 4	1.32	205	333
										Day 5	1.31	212	268
B5	445	3	16.7	6	4	3	9	82	1	Day 1	1.14	105	81
										Day 2	1.14	95	75
										Day 3	1.14	94	68
										Day 4	1.13	101	92
										Day 5	1.15	92	71
B6	905	5	30	15	5	9	57	222	1	Day 1	1.06	102	131
										Day 2	1.06	77	210
										Day 3	1.05	86	206
										Day 4	1.05	91	173
										Day 5	1.07	81	192

Table 3: Numerical values for five days samples from the fifteen days collecting data in the old campus of Sulaimani University campus

Selected Teaching Buildings	walkway length (WL)	walkway width (WW)	Walkway Level (WH)	Walkway intersecting Walkway (WIW)	Walkway intersecting street (WIS)	Walkway intersecting space (WIO)	Furniture No. (Fu No.)	Tree No. (T. No.)	Walkway Finishing (FI)	Data Collection Days	Average Speed per day (S)	Ped. Group No. (PG. No.)	Ped. Alone No. (PA. No.)
B7	162	2.5	4.6	4	3	3	33	17	0	Day 1	1.39	152	211
										Day 2	1.38	155	196
										Day 3	1.38	171	202
										Day 4	1.39	156	208
										Day 5	1.41	148	231
B8	200	2.5	5.7	5	4	4	35	32	0	Day 1	1.37	41	43
										Day 2	1.37	35	41
										Day 3	1.35	42	40
										Day 4	1.38	33	51
										Day 5	1.36	36	52
B9	126	3	6	5	3	2	14	27	0	Day 1	1.34	75	183
										Day 2	1.34	72	171
										Day 3	1.34	85	151
										Day 4	1.35	71	175
										Day 5	1.36	83	153
B10	177	3	7.45	3	2	3	10	26	0	Day 1	1.32	61	163
										Day 2	1.32	75	155
										Day 3	1.35	83	128
										Day 4	1.33	81	133
										Day 5	1.33	72	161

After collecting and calculating data about physical variables of pedestrians and campuses (see Tables 2 and 3), SPSS 20 software was used to perform multiple linear regression to show the relationship between pedestrian speed and all other related variables. Further, this was used to establish a model for pedestrian speed that considers both the dependent and independent variables found in Table 1. According to the regression analysis results shown in Table 4, pedestrian speed is affected in different ratios by other variables.

Linear regression models are generally expressed as follows:

$$\boldsymbol{\gamma} = \alpha + b_1 X_1 + b_2 X_2 + b_3 X_3 + \ldots\ldots + b_n X_n \,. \qquad \textbf{(3)}$$

Where Y is the predicted or expected value of the dependent variable, *X1* through *Xn* are (n) distinct independent or predictor variables, α is called the intercept or constant and is the value of *Y* when all of the independent variables (*X1* through *Xn*) are equal to zero, and *b1* through *bn* are the estimated regression coefficients (Beta). Each regression coefficient represents the change in *Y* relative to a one-unit change in the respective independent variable. Based on the regression analysis from Table 4, the following model for pedestrian speed was created:

$$\boldsymbol{\gamma} = \mathbf{4.368 - 0.173WL + 0.185WW - 0.706WH - 0.317WIW - 1.17WIS + 0.227WIO - 0.336Fu - 0.185T - 0.016Fi + 0.1057PA - 0.148PG} \quad \mathbf{(4)}$$

Table 4. Results of the multiple linear regression analysis for pedestrian speed

Model		**Standardized Coefficients**			**t**	**Sig**
Dependent variable	**Independent variable**	**Constant**	**Beta**	**Std. Error**		
S (Pedestrian speed)		4.368				
	WL		-0.173	0.362	-2.011	0.046
	WW		0.185	0.407	-5.243	0
	WH		-0.706	0.206	-7.944	0
	WIW		-0.317	0.108	-7.536	0
	WIS		-1.17	0.462	0.208	0.836
	WIO		0.227	0.312	2.213	0.028
	Fu		-0.336	0.012	-4.32	0
	T		-0.185	0.069	-1.954	0.053
	Fi		-0.716	0.013	-8.079	0
	PA		1.057	0.186	1.024	0.012
	PG		-0.148	0.241	-0.347	0
				2.378		

From the regression analysis results from Table 4, it is clear that walkway characteristics have impacts on pedestrian speed with different ratios. An intersection with a street (WIS) has the most impact on speed (-1.17). This means that a walkway intersecting a street reduces pedestrian speed with a ratio of -1.17. The impacts of other walkway characteristics are shown in Model (4). Comparing these results with the data in Tables 2 and 3 shows that the average pedestrian speed for the selected buildings on the old campus of Sulaimani University is 1.36 m/s while the average pedestrian speed for the selected buildings on the new campus is 1.21 m/s. This shows that the average pedestrian speed on the new campus is slower than on the old campus and slower than the average human walking speed of 1.33 m/s due to impacts of the walkway characteristics. Table 5 shows the differences between averages for variables related to both walkway characteristics and pedestrians for each university campus.

Table 5. Comparison of calculated data between both University Campuses

University Campus	walkway length (WL)	walkway width (WW)	walkway Level (WH)	walkway intersecting walkway (WIW)	walkway intersecting street (WIS)	Walkway intersecting space (WIO)	Furniture No. (Fu)	Tree No. (T)	Walkway Finishing (FI)	Delay (D)	Ped. Group (PG. No.)	Ped. Alone (PA. No.)
New campus	580	2	17.8	7.5	4	3.5	12.5	101	1	0.12	177	206
Old campus	166	2.75	5.94	4.25	3	3	23	25.5	0	0	88	140

7 Conclusion

Pedestrian speed as a dependent variable is affected by both human characteristics such as age, gender, health, and physical ability and characteristics of the built environment. In regard to the impacts of the built environment, especially on university campuses, there are various physical characteristics that affect pedestrian speed, such as pedestrian infrastructure characteristics, spatial arrangement type, and master plan type of the campus.

Pedestrian speed is negatively correlated with highest value and affected by walkway intersecting street (WIS) with weight (- 1.17) which means that pedestrian speed decreases when the walkway intersect streets. This is because pedestrians always pause for a while when streets intersect his/her walking path for safety. This causes speed decrease and results pedestrian delay.

Pedestrian speed is negatively and significantly affected by walkway level (slope) (WH) with weight (– 0.706), this is because walkway slope more than (5%) is very hard for pedestrian to walk for a long distance.

Pedestrian speed is negatively affected by the number of furniture (Fu) on walkways with weight (-0.336), which means speed decreases with the increase of furniture number on walkways and vice versa. This is because pedestrian would slow down his/her speed to find some furniture when needed while walking such as seeking for a dustbin or any other furniture when needed.

Pedestrian speed is negatively and significantly correlated and affected by walkway intersecting walkway (WIW) with weight (– 0.317) which means that pedestrian speed decreases when the walkway on intersect another. This is because pedestrian speed slows down when a walkway intersects another walkway due to mixing both walkways pedestrians that slows down the speed and results in pedestrian delay.

Pedestrian speed is positively correlated and affected by walkway intersecting open spaces (WIO) with weight (0.227) which means that pedestrian speed increases when the walkway intersect an open space or a building layout or when the number of such intersections increases and vice versa. This is because pedestrian speed increases due to more feeling in open area and walkways have least intersections.

Pedestrian speed is negatively affected and correlated by the number of trees (T) on the walkway with weight (– 0.185) this is because trees are mostly used for beautification and comfort factors where pedestrian speed slows down due to feeling comfort.

From the results of the study, it can be concluded that spatial arrangement and master plan type have impacts on pedestrian speed. This is a characteristic of walking infrastructure related to the type of campus spatial organisation and type of master plan. As in the elliptical master plan which building distribution has a linear-type, walkway length increases, the number of intersections with streets also increases, which reduces pedestrian speed consequently.

The results show that pedestrian speed on the old campus of Sulaimani University, which has a compact and clustered (i.e., place making (building dominated)) spatial organisation, is higher than pedestrian speed on the new campus, which has an elliptical spatial organisation where teaching buildings are distributed on a curvilinear street. Pedestrians on both campuses are of the same age, gender, and social level as they are students.

According to the results, the intersection of a walkway with a street (WIS) has the greatest negative impact on pedestrians.

Acknowledgments: The authors would like to acknowledge the University of Sulaimani that let the authors to record pedestrian movement for 15 days and give all necessary master plan drawings for this article.

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