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ENHANCING STUDENTS' CAMPUS WALKABILITY AS A SUSTAINABILITY INDICATOR

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Abstract

Introduction: Walking has recently become an essential and sustainable way of mobility for university students in their daily lives. The walkability of students is affected by the characteristics and context of the campus's built environment. **Purpose of the study:** The purpose of the study is to determine the time benchmarks needed to classify the students' campus walkability and study the factors that affect students' campus walkability, which include four groups: campus infrastructure, campus layout, context and services, and students' behavior. **Methods:** A questionnaire was distributed to students at the Faculty of Engineering at the AABU University in Mafraq, Jordan. SPSS software was used to analyze the data and obtain results. **The results** of the study show that students' walkability can be divided into the following categories: convenient walkability, tolerable walkability, and weary walkability. Meanwhile, the factors are grouped into those that increase, decrease, or have no effect on students' campus walkability. The significance of the research lies in the investigation of walkability as one of the primary modes of mobility on the university campus. It is considered an essential component of sustainability and is used as a design consideration for determining accessibility to the various services that students need within the university.

Keywords: sustainability; walkability; walking behavior; campus walkability.

Introduction

Walkability is an essential component of urban development. It also offers unexpected health, environmental, financial, and community benefits. The term "walkability" refers to a method that assesses how pedestrian-friendly a location is.

Several studies have examined issues related to students' campus walkability (Peachey and Baller, 2015). To begin, a literature review was conducted to investigate the concept of walkability, which is defined as the relevance of the built environment to human behavior, whether for living, shopping, visiting, enjoying, or spending time (Abley, 2005).

One of the goals is to determine the factors that affect students' walkability. The study classifies these factors into four groups, including campus infrastructure, campus layout, context and services, and students' behavior. In general, most universities include a variety of facilities and spaces that enable students to learn and walk. These facilities can be classified in various ways; some studies divide them into academic and non-academic services. Another option is based on students' priorities and frequency of use per week.

The AABU University in Mafraq, Jordan, was selected as a case study. It includes 13 faculties and a variety of facilities. Based on Akomolafe and Adesua (2016), the campus services were classified into two groups: academic services and non-academic services (Fig. 1).

Another aspect is to review the measuring tools that the researchers used to assess walkability and establish the most appropriate model that can serve the study objective of measuring the students' campus walkability. For example, Frank et al. (2010) proposed a walkability index, and Dörrzapf et al. (2019) described other tools such as audit-based methods, sensors for walkability assessment, geodata analysis, and Walk Score.

The ability to walk decreases over time, resulting in different levels of walkability. These include convenient walkability, when students can walk comfortably; tolerable walkability, when students walk feeling tired; and weary walkability, when students cannot walk any longer.

The main goals of this study are to:

1. Determine the time benchmarks needed to classify students' campus walkability into weary walkability, tolerable walkability, and convenient walkability.

2. Study the factors that affect students' campus walkability.

The literature review examines several aspects of walkability: firstly, studies that determine the factors affecting walkability, such as Grasser et al. (2016) and Koschinsky and Talen (2015); secondly, studies that determine the walkability measurement

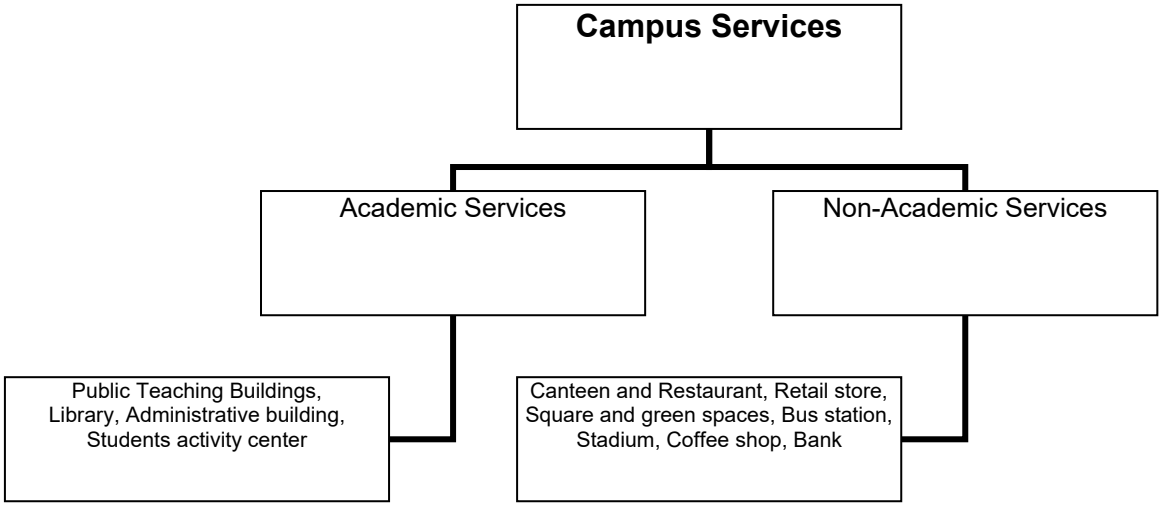


Fig. 1. Campus services

tools, such as Zhang et al. (2020), Saghapour et al. (2017), and King et al. (2020); and finally, studies on campus walkability, such as Sisson et al. (2008) and Peachey and Baller (2015).

Literature Review

This section will discuss the concept of walkability, walkability measurement tools, campus walkability, and campus services.

1. Walkability: definitions and tools

Walking has recently become an essential and sustainable way of mobility for university students in their daily lives. Sustainability aims to create a healthy environment by promoting an active lifestyle and increasing accessibility and freedom of choice by making more facilities accessible (Eshruq Labin et al., 2022).

Walkability is defined as the relevance of the built environment to human behavior, whether for living, shopping, visiting, enjoying, or spending time (Abley, 2005; Frank and Engelke, 2005). It is an important aspect of personal cognition and social coexistence. Besides, walkability is an important consideration in designing public spaces (Ewing and Handy, 2009).

Several studies have found a correlation between public health and a city's walkability. Furthermore, walkability enhances leisure and mobility (Brownson et al., 2009; Dörrzapf et al., 2019; Grasser et al., 2016; Sarkar et al., 2018). Neighborhood walkability is defined as the ability to support physical activity while considering residential density and city block size, as well as access to various destinations, street connectivity, sidewalk access, aesthetics, and other community features. Meanwhile, more detailed elements could also be studied, such as pedestrian safety and comfort, walking preferences, and friendliness for walking in a walkable environment (Zhang et al., 2020).

According to Clarence Perry, the unit of measurement for walking distance is 400 meters, or a five-minute walk, which is the walkability from a school to a residential area. However, it is not suitable for some countries that have hot or cold climate. For example, in Malaysia, the preferred distance to walk before choosing to drive is 200 meters (Azmi and Karim, 2012). Walkability refers to a pedestrian's ability to walk short distances of less than 100 meters for a certain reason, such as going to work or school (Dörrzapf et al., 2019).

Walkability encompasses measurable functional and physical requirements as well as subjective walkability features, including the importance of personal preferences and individual perceptions of the environment (Dörrzapf et al., 2019). To study the relationships between walkability and physical environmental aspects, Lee and Moudon (2006) divided the elements that affect walkability into 13 VIP (variables with strong theoretical support) and 19 non-VIP (built environment variables) variables. The linkages with the physical elements of an environment are based on walking purposes. Forsyth et al. (2008) listed over 200 factors that influence walkability, including street pattern, pedestrian-oriented design elements, and attractions.

Walkability can be quantified in various ways, including the opportunities to walk in a particular environment and walking behavior. Thus, the results of the experience are affected by what people perceive while walking, which means there is a strong relationship between walking behavior and perceptual qualities (Ewing and Handy, 2009; Dörrzapf et al., 2019). Knapskog et al. (2019) categorized the factors that affect walkability into three groups: infrastructure and traffic, urbanity, and surroundings and activities.

Walking experience is a tool that is used to assess walking behavior. Safety, convenience, and pleasure are aspects of a good walking experience that enhance the walkability of an area. Moreover,

familiarity with an area increases comfort while walking (Azmi and Karim, 2012).

Walking behavior refers to a pedestrian's performance in terms of walking duration and route selection. Walking behavior takes several forms due to a variety of factors that influence pedestrian behavior (Azmi and Karim, 2012). Another aspect that influences walkability is the walking distance, which affects walkers' comfort and willingness to walk. The walking distance can be measured from the origin to the destination in miles or meters, or in minutes (Mohamaddan, 2010).

Azmi and Karim (2012) investigated two characteristics of the walking experience, namely safety and convenience. They are based on the World Bank's Global Walkability Index (GWI), which is a metric that measures the walkability of a neighborhood. Security, motorist behavior, and crossing exposure are all part of the safety component, while visual appeal, pedestrian amenities and coverage, and connectivity are all part of the convenience component. The researchers used walking distance, time taken to walk, walking formation, strategic position, accessibility, and walking experience to assess walking behavior.

Frank et al. (2010) proposed a walkability index that considers density, land use mix, and retail floor area ratio. Glazier et al. (2012) also proposed a walkability index for Canadian settings, emphasizing residential housing density, population density, roadway connectivity, and retail outlet density. Moreover, the impact of several criteria on walkability, such as street connectivity, destination accessibility, aesthetics, pedestrian facilities, residential density, safety, and land use mix, was investigated (McCormack and Shiell, 2011; Grasser et al., 2016).

A pedestrian-friendly index combines four sub-indices: land use density index, population density index, commercial density index, and intersection density index (Peiravian et al., 2014). Whereas, a walking access index (WAI) studies the effect of travel distance and walking time on walkability (Saghapour et al., 2017).

Several methods exist for assessing walkability, such as audit-based methods, sensors for walkability assessment, and geodata analysis. Audit-based methods are used to assess walkability and urban space using a rating system for various parameters, such as walking distance, proportions of green space, and traffic volume (Brownson et al., 2009; Krenn et al., 2015). An audit-based method is based on movement-specific models, which study the effects of social, individual, and physical settings, as well as aspects of functionality, safety (personal safety and traffic safety), aesthetics, and business or service (Dörrzapf et al., 2019; Long et al., 2018; Pikora et al., 2003).

Sensors for walkability assessing are used to analyze walkability and how people use public spaces. They include permanently installed, mobile, and biosensors. Pedestrians' behavior in urban spaces can be observed through a mobile or permanently installed camera and permanently installed sensors. Smartphone sensors can be used to collect data either directly from users via surveys or questionnaires, such as the eDiary app, which is used to acquire subjective assessments of walkability, or indirectly by tracking the environment.

Generally, this method is not ideal for measuring walkability since data protection makes it difficult to access the information. Biosensors, for example, provide objective measurements of skin conductance and skin temperature (Dörrzapf et al., 2019; Resch et al., 2020; Zhou and Long, 2017).

Geodata analysis is an objective evaluation of pedestrian movements and interactions. It is used to assess urban walkability by analyzing traditional and urban geodata related to walkability, enabling data to be spatially and temporally referenced. Urban functions, land use categories, street network, road widths, traffic volumes, green index, and population are all included in the geodata study. Dörrzapf et al. (2019) used a comprehensive approach to assess walkability by combining existing qualitative and GIS-based techniques with biosensor technologies to capture the impact of the physical environment on pedestrians' perceptions and emotions.

GIS-based approaches for measuring walkability, such as network analysis, distance-based, gravity-based, potential-, topology-, or infrastructure-based methodologies, are widely used to analyze the spatial accessibility of a single facility or several facilities (Vale, 2015). The Integrated Spatial Equity Evaluation (ISEE) examines the spatial equality of diverse community facilities (Taleai and Yameqani, 2018).

Walkability assessment utilizes field audits, qualitative analysis, and quantitative empirical research to examine the relationship between walking and health, the environment, the economy, and social aspects (Reyer et al., 2014).

Zhang et al. (2020) used a subjective evaluation method of walkability based on questionnaires, an objective evaluation method based on field audits, and an integrated method combining subjective and objective approaches. They also proposed a walkability index method that incorporating various environmental features such as land use mix, residential density, and street connectivity to assess pedestrian walkability.

Walk Score has recently gained international recognition as an essential quantitative measurement technique for a variety of reasons, including evaluating the time and distance required to walk to destinations. It also considers the number and type of facilities,

as well as their layout pattern. To adjust the value, Walk Score takes into account population density, street length, and intersection density. Using a standardized scale of 0–100, with higher values indicating a more walkable environment, Walk Score divides that scale into five intervals: 0–24 car-dependent, 50–69 somewhat walkable, 70–89 very walkable, and 90–100 walker's paradise (Zhang et al., 2020).

Walk Score is used by many researchers to evaluate various aspects of walkability, the living environment, urban design features and qualities, physical activity, affordability, and walking behavior. Walk Score is an international walkability measurement metric based on block length, street connectivity, and facility layout (Wu and Shen, 2017; Zhang et al., 2020). However, Walk Score has not been used as an acceptable way to evaluate a pedestrian's walkability in the campus environment. The most important study that used Walk Score to measure the students' campus walkability is by Zhang et al. (2020), which is the main reference for this research.

2. Campus walkability and campus facilities

Generally, universities have several facilities and spaces that are likely to encourage students to learn and be walkable, such as classrooms, libraries, hostels, shuttle buses, cafeterias, clinics, cultural facilities, prayer rooms, security guard posts, laboratories, games and sports facilities, farms and gardens, restrooms, information and communication technologies (ICT), transportation and security, and counseling centers. These can be categorized into two groups: academic services and non-academic services (Akomolafe and Adesua, 2016).

Ramli and Mohd Zain (2018) examined the effect of campus facilities on students' achievements. They explored three factors that can impact students' achievements: system management (e-learning, management information system), learning environment (classrooms, teaching aids, and library), and infrastructure (hostels, sports facilities, parking and transportation).

Easy way-finding is one of the factors that affects walkability. Students' way-finding behavior on campus is influenced by several factors grouped into individual factors and built environment legibility factors. The built environment legibility factors include such elements as architectural features, visual communication features (graphical), audible communication (verbal) features, and tactile features (Eshruq Labin, 2020).

Campus walkability studies serve a variety of goals, including assessing walkability on a single campus, comparing two or more campuses, and comparing on-campus and off-campus built environments. Two methodologies, subjective and objective, were employed to evaluate campus walkability in two directions. The first direction focuses on the university campus built environment. The walkability and bikeability of the University of North Texas campus streets were assessed by Li et al. (2016). King et al. (2020) used a different method to assess campus walkability by combining participants' perceptions of walkability, environmental factors, and other physical activity-related features on campus.

The second direction involves the subjective evaluation of walkability in relation to campus walkability, students' physical activity, built environment features, social aspects, and travel modes. Scholars have primarily used audit tools, such as pedestrian environment data scan and cycling environmental scan (Zhang et al., 2020).

Various environmental factors, such as residential density, land use mix, aesthetics, safety, and existing infrastructure such as sidewalks and walking routes, were investigated to determine how they affect walkability, walking behavior, and walking activity intensity (Iakimovich et al., 2022; Peachey and Baller, 2015). Peachey and Baller (2015) revealed in their study that the campus built environment elements have an impact on students' physical activity. They found that a campus with land use mix diversity, aesthetics, and a lack of cul-de-sacs can enhance students' physical activity. Furthermore, some research examines how walkability affects students' physical activity in terms of proximity to facilities and perceived safety (Peachey and Baller, 2015).

Students who reside on a campus with wide streets and restricted access to destinations had lower walking intensity than those who live on a campus with main academic areas, many destinations, and few parking lots (Sisson et al., 2008). Furthermore, studies have focused on the effects of a destination's geographical location on walkability and the level of access to various destinations in order to investigate the link between campus walkability and commuting modes. Students prefer to walk or bike to campus in areas with strong walkability and a dense service infrastructure (Vale, 2015).

Walking speed, walking directions, walking experiences, group formation, and density are five elements that demonstrate walking behavior. However, only three parameters were utilized to examine walking behavior on the campus of UNIKA St. Thomas University: walking distance, walking time, and walking speed. The average walking speed is 1.40 meters per second, and it is determined by numerous factors such as age, gender, height, and weight. Walking distance is the distance that can be covered on foot within a certain amount of time. It is commonly used in planning as a benchmark for a comfortable walking distance of 400 meters, which takes about five minutes. Walking time is influenced by many factors, such as gender, age, health and leisure (Silitonga, 2020).

Zhang et al. (2020) developed a campus walkability evaluation tool that enhances the Walk

Score approach by taking into account the variety, frequency, and distance that students travel to and from public facilities.

Methodology

1. Study setting

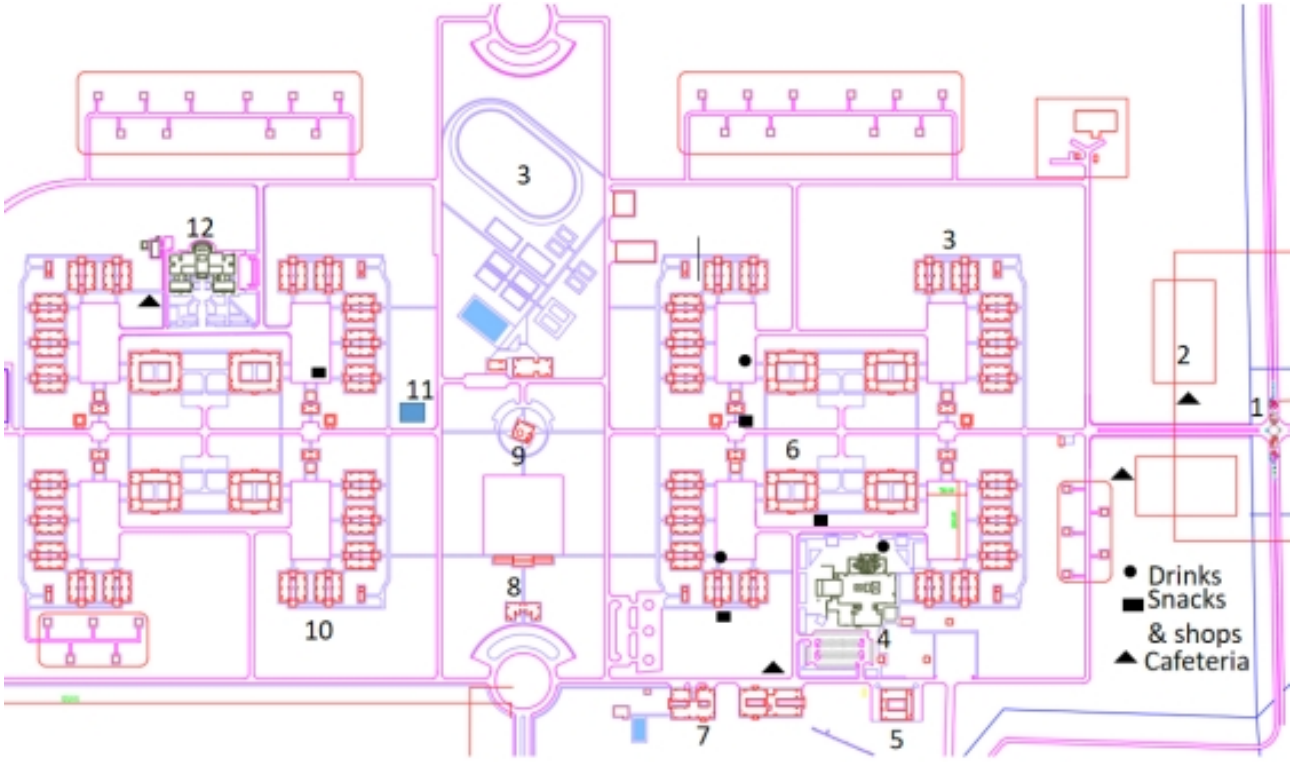
This study took place on the large urban campus of AABU, located 65 kilometers northeast of Jordan's capital, Amman. The campus spans over 7,539,000 square meters in Mafraq. AABU University comprises several faculties, including the Faculty of Engineering, the Princess Salma Faculty of Nursing, the Faculty of Information Technology, the School of Business, the Faculty of Sharia, the Faculty of Law, the Faculty of Arts and Humanities, the Faculty of Science, the Faculty of Educational Sciences, the Faculty of Political Sciences and International Studies (Bayt Al-Hikmah), the Faculty of Earth and Environmental Sciences, and the Institute of Astronomy and Space Sciences (Fig. 2).

In addition to the faculties' buildings, there are many service buildings inside the campus, such as a bank, a mosque, and an elementary school for the children of university employees (Al Abrar School).

2. Participants

AABU University comprises nearly 19,455 students pursuing doctorate, master's, and bachelor's degrees, with 11,308 of them being female and 8,147 male (for the academic year 2021/2022). Among them, 1,297 students are registered at the Faculty of Engineering, 406 at the Architecture Engineering Department, 404 at the Civil Engineering Department, 319 at the Renewable Energy Engineering Department, and 150 at the Surveying Engineering Department (Al al-Bayt University Annual Report 2020/2021, 2021).

The survey assesses students' campus walkability from the Faculty of Engineering to various campus services. A total of 372 participants from the Faculty of Engineering responded to the questionnaire, with 219 being female and 153 being male. Among the participants, 11 % are in their first year, 30 % in the second year, 27 % in the third year, 31 % in the fourth year, and 1 % in the fifth year. Additionally, 41.8 % of the participants are from the Architecture Engineering Department, 27.6 % from the Civil Engineering Department, 15.3 % from the



1	Main gate	7	Student activity center
2	Faculty of Engineering	8	University Presidency building
3	Elementary school	9	Mosque
4	Quraish building	10	Students' housing
5	Registration department	11	Bank
6	Al-Hashemite library	12	Hashem building

Fig. 2. Campus master plan

Renewable Energy Engineering Department, and 15.3 % from the Surveying Engineering Department.

3. Data collection

This study is mainly based on a literature review to collect secondary data. Subsequently, questionnaires were distributed to the students of the Faculty of Engineering at AABU University. The questionnaire is structured into four parts:

1. Demographic data, including gender, department, and study year.
2. Frequency of using campus services by students.
3. Time needed to reach various student destinations from the Faculty of Engineering and time required to determine the benchmarks for classifying walkability.
4. Factors affecting students' campus walkability.

To determine the time benchmarks for classifying students' campus walkability, a specific conceptual methodology is used, following the sequence below:

1. Determining the actual time that students need to access various university services from the Faculty of Engineering.
2. Determining the walkability type experienced by students during the walking trip to access various university services from the Faculty of Engineering.
3. Determining the time benchmarks required for each type of walkability by students. Walkability is categorized into three groups: weary walkability, tolerable walkability, and convenient walkability.
4. Estimating the walkability type required to reach each service based on the actual time determined in step No. 1, using the time benchmarks determined in step No. 3.
5. Comparing the walkability type in step No. 2 with the walkability type in step No. 4 to study the consistency of the results.

The students' campus walkability factors were clustered into four groups, including:

1. The campus infrastructure includes traffic aspects such as street features, street intersections, street furniture, vehicle density, pollution, noise, car parks, and the availability of public transit.
2. The campus layout includes aspects that form the campus master plan, such as the proximity of buildings, interconnection of spaces, open spaces, building orientation, building scale, building permeability, pedestrian pathway networks, green areas, and student density since the distribution of functions affects student density.
3. Context and services include the style and quality of the service, such as the type of function (library, restaurant, etc.), building design, building facades, diversity of services, place vitality, destinations, and regular maintenance.
4. Students' behavior includes safety, way-finding, walking alone, students' walking or staying, and walking with friends.

Results

Zhang et al. (2020) divided the average frequency of using various facilities per week into three categories: high frequency (more than five times a week), medium frequency (more than one time a week), and low frequency (less than one time a week). After comparing the non-academic services, the results show that the bus station falls under the high frequency category due to its functional necessity. A comparison was then made between the cafeterias, revealing that the engineering cafeteria is of medium frequency use due to its proximity, while the business cafeteria and other cafeterias are of low frequency use. This proves that as the distance increases, the desire to walk decreases. Meanwhile, other facilities fall under the low frequency category (Table 1).

When comparing services based on the time it takes to reach them, the engineering cafeteria is the closest, only 5 minutes away, which is of medium frequency. The time required to reach the business cafeteria is 6–10 minutes, and it is of low frequency. Other cafeterias and coffee shops are 16–20 minutes away and of low frequency. The bus station is 6–10 minutes away and of high frequency. The bank, student activity center, registration building, and library are 16–20 minutes away and of low frequency. The Okath shop is 26–30 minutes away and of low frequency, and the stadium is more than 30 minutes away and of low frequency as well.

The walking distance was measured from the origin (Faculty of Engineering) to destinations in meters (when walking on foot) and minutes. The time required to reach various services from the Faculty of Engineering was determined by the students (Table 2). For instance, 98.9 % of the students need 5 minutes to access the engineering cafeteria, 73.1 % of the students need 6–10 minutes to access the business cafeteria, and 69.9 % of the students need the same amount of time to reach the bus station. Additionally, 46.2 % of the students need 6–10 minutes to reach the public halls.

Besides, 67.7 % of the students need 16–20 minutes to reach the AlRefadeh Wa AlSeqayeh cafeteria; 51.6 % of the students need 16–20 minutes to reach the Hashem cafeteria; and 57.0 % of the students need 16–20 minutes to reach the Iqbal cafeteria. Additionally, 16–20 minutes are needed to reach the Quraish coffee shop, nursing coffee shop, IT coffee shop, Hashemite coffee shop, Hashemite library, student activity center, bank, and registration building.

The percentages were 67.7, 51.6, 57.0, 46.2, 59.1, 55.9, 63.4, 59.1, 51.6, 53.8 and 48.4 %, respectively.

In addition, 49.5 % of the students need 26–30 minutes to reach the Okath shop, and 48.4 % of the students need more than 30 minutes to get to the stadium.

Table 1. **Frequency of facilities use**

Campus services			Frequency of use per week, %		
			Less than once a week	1–4 times a week	More than 5 times a week
Non-academic services	Cafeterias	Engineering cafeteria	8.6	55.9	35.5
		Business cafeteria	46.2	45.2	8.6
		AlRefadeh wa AlSeqayeh cafeteria	90.3	7.5	2.2
		Hashem cafeteria	93.5	6.5	0
		Iqbal cafeteria	77.4	20.4	2.2
	Coffee shops	Quraish coffee shop	51.6	41.9	1.1
		Nursing coffee shop	87.1	12.9	0
		IT coffee shop	91.4	8.6	0
		Hashemite coffee shop	91.4	8.6	0
	Okath shop		73.1	25.8	1.1
	Bus station		17.2	29.0	53.8
	Stadium		92.5	6.5	1
	Bank		68.8	30.1	1.1
Academic services	Student activity center		90.3	9.7	0
	Registration building		64.5	34.4	1.1
	Public halls		52.7	38.7	8.6
	Hashemite library		57.0	41.9	1.1

Due to the inverse relationship between time and walkability, walkability decreases as time increases. Therefore, walkability was divided into three groups: convenient walkability, when students can walk comfortably without feeling tired; tolerable walkability, when students can walk despite feeling tired; and weary walkability, when students can no longer walk due to tiredness (Fig. 3).

The students determined the time benchmarks for convenient, tolerable, and weary walkability. The minimum value given by the students for convenient walkability is 2, which corresponds to 6 to 10 minutes. The maximum value is 6, indicating 26–30 minutes, while the mean is 3.5, indicating that the students walk for 15 minutes without feeling tired (Tables 3, 4).

The minimum value given by the students for tolerable walkability is 3, which means 11–15 minutes, while the maximum value is 9, which means 41–45 minutes. The mean is 6.04, indicating that the students feel tired after walking for 15 to 30 minutes (Tables 3, 4).

The minimum value given by the students for weary walkability is 5, which means 21–25 minutes, while the maximum value is 11, which means more

Table 2. **Time needed to reach the services**

Campus services	Time needed to reach the services (in minutes)						
	5	6–10	11–15	16–20	21–25	26–30	30<
Engineering cafeteria	98.9	1.1	–	–	–	–	–
Business cafeteria	21.5	73.1	5.4	–	–	–	–
AlRefadeh wa AlSeqayeh cafeteria	–	–	28.0	67.7	4.3	–	–
Hashem cafeteria	–	–	28.0	51.6	20.4	–	–
Iqbal cafeteria	–	–	29.0	57.0	14.0	–	–
Quraish coffee shop	–	–	31.2	46.2	22.6	–	–
Nursing coffee shop	–	–	24.7	59.1	16.1	–	–
IT coffee shop	–	–	36.6	55.9	7.5	–	–
Hashemite coffee shop	–	–	19.4	63.4	17.2	–	–
Okath shop	–	–	–	–	21.5	49.5	29.0
Bus station	24.7	69.9	5.4	–	–	–	–
Stadium	–	–	–	–	22.6	29.0	48.4
Bank	–	–	23.7	53.8	22.6	–	–
Student activity center	–	–	33.3	51.6	15.1	–	–
Registration building	–	–	36.6	48.4	15.1	–	–
Public halls	–	46.2	41.9	11.8	–	–	–
Hashemite library	–	–	25.8	59.1	15.1	–	–

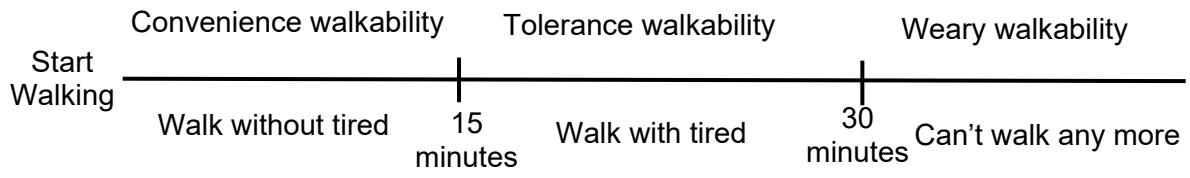


Fig. 3. Students' walkability types

Table 3. **Time needed to reach the services to classify walkability**

Type of walkability	Time (minutes)									
	0–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50
Convenient walkability	–	12.9 %	31.2 %	48.4 %	6.5 %	1.1 %	–	–	–	–
Tolerable walkability	–	–	3.2 %	8.6 %	16.1 %	38.7 %	20.4 %	11.8 %	1.1 %	–
Weary walkability	–	–	–	–	1.1 %	5.4 %	4.3 %	3.2 %	11.8 %	41.9 %

Table 4. **Maximum and minimum walkability values**

Type of walkability	Minimum distance	Maximum distance	Mean
Convenient walkability	2.00	6.00	3.5161
Tolerable walkability	3.00	9.00	6.0430
Weary walkability	5.00	11.00	9.7419

than 51 minutes. The mean is 9.7, indicating that the students cannot walk any more after 30–45 minutes (Tables 3, 4).

The students considered walkability convenient while walking from the Faculty of Engineering to the engineering cafeteria, business cafeteria, bus station, and public halls. They also considered walkability tolerable for the AlRefadeh wa AlSeqayeh cafeteria, Hashem cafeteria, Iqbal cafeteria, Quraish coffee shop, nursing coffee shop, IT coffee shop, Hashemite coffee shop, Okath shop, Hashemite library, student activity center, bank, and registration building. Walkability to reach the stadium was considered weary (Table 5).

Table 5. **Determining the walkability type to reach the campus services**

Campus services	Type of walkability		
	Convenient	Tolerable	Weary
Engineering cafeteria	98.9	1.1	0
Business cafeteria	97.8	2.2	0
AlRefadeh wa AlSeqayeh cafeteria	20.4	76.3	3.3
Hashem cafeteria	10.8	64.5	24.7
Iqbal cafeteria	24.7	67.7	7.6
Quraish coffee shop	45.2	52.7	2.1
Nursing coffee shop	28.0	67.7	4.3
IT coffee shop	20.4	75.3	4.3
Hashemite coffee shop	22.6	72.0	5.4
Okath shop	3.2	55.9	40.9
Hashemite library	23.7	69.9	6.5
Bus station	90.3	8.6	1.1
Stadium	4.3	47.3	48.4
Student activity center	20.4	71.0	8.6
Bank	17.2	68.8	14.0
Registration building	30.1	67.7	2.2
Public halls	53.8	39.8	6.4

The next step was to examine the congruence between the walkability type based on the students' experience (when walking between the Faculty of Engineering and other services) and the walkability type based on the time needed to reach the services. The results show that they are congruent (Table 6).

The factors that affect students' campus walkability can be grouped into four categories. The first group contains the factors related to the campus infrastructure. The results show that 48.4 % of the students believe that street features, such as the width of the street, increase walkability. Besides, street furniture such as benches, lighting, and waste paper baskets increases walkability. In addition, 45.2 % of the students concluded that the street intersection did not affect the level of walkability. Meanwhile, 63.4 % of the students believe that the density of vehicles on campus decreases walkability (Table 7).

It also should be noted that 67.7 % of the students believe that pollution and noise decrease walkability, while 34.4 % of the students concluded that the design and architectural style used for the buildings on campus did not affect students' walkability. Additionally, 48.4 % of the students believe that the availability of public transportation within the campus decreases their desire to walk (Table 7).

As for the second group of factors related to the campus layout, 41.9 % of the students believe that the density of students has no effect, while 52.7 %

Table 6. **Walkability congruency**

Campus services	Type of walkability			Congruency
	Walkability based on the students' experience	Average time needed to reach the services	Walkability based on the time needed to reach the services	
Engineering cafeteria	Convenient	5	Convenient	Congruent
Business cafeteria	Convenient	6–10	Convenient	Congruent
AlRefadeh wa AlSeqayeh cafeteria	Tolerable	16–20	Tolerable	Congruent
Hashem cafeteria	Tolerable	16–20	Tolerable	Congruent
Iqbal cafeteria	Tolerable	16–20	Tolerable	Congruent
Quraish coffee shop	Tolerable	16–20	Tolerable	Congruent
Nursing coffee shop	Tolerable	16–20	Tolerable	Congruent
IT coffee shop	Tolerable	16–20	Tolerable	Congruent
Hashemite coffee shop	Tolerable	16–20	Tolerable	Congruent
Okath shop	Tolerable	26–30	Tolerable	Congruent
Hashemite library	Tolerable	16–20	Tolerable	Congruent
Bus station	Convenient	6–10	Convenient	Congruent
Stadium	Weary	More than 30	Weary	Congruent
Student activity center	Tolerable	16–20	Tolerable	Congruent
Bank	Tolerable	16–20	Tolerable	Congruent
Registration building	Tolerable	16–20	Tolerable	Congruent
Public halls	Convenient	11–15	Convenient	Congruent

emphasize that the proximity of buildings on the campus increases walkability. Additionally, 57 % of the students considered the spatial connection to increase walkability. The campus covers 7,539,000 square meters, which is considered a large area. It should be noted that 66.7 % of the students stated that this reduces walkability. Meanwhile, 45.2 % of the students believe that the building orientation and building scale have no effect. Building permeability facilitates students' movement through the campus and helps them find shortcuts, ultimately increasing walkability. It should be noted that 47.3 % of the students acknowledged this. Additionally, 71.0 % emphasized that the accessibility of pedestrian pathways connecting various campus services contributes to walkability, while car parks have no effect on it. Furthermore, 69.9 % highlighted that the availability of open spaces and green areas increases students' desire to walk (Table 7).

Most context and service group factors increase walkability. It should be noted that 52.7 % of the students believe that the proximity of their destinations increases walkability. The closer the destination, the greater the desire to walk. Additionally, the type of activity, such as dining, visiting the library, doing sports, and studying, also increases walkability. Two factors have no effect on walkability, including when students are walking along the pedestrian paths or sitting at the squares, as well as the building facades. It should be noted that 52.7 % of the students emphasized that service diversity increases walkability; as a result, the greater the number of facilities, the greater the diversity of services. In addition, 78.5 % of the students highlighted the role of place vitality in increasing walkability, and 57 % said that the regular maintenance of public services and utilities increases walkability (Table 7).

The last group is the students' behavior factors. It should be noted that 81.7 % of the students emphasized that feeling safe increases walkability and ease of way-finding. Additionally, 38.7 % of the students believe that walking alone has no effect on walkability, while 74.2 % stated that walking with friends increases the desire to walk. The hot or cold weather factor is one of the most important factors affecting students' walkability; 77.4 % of the students believe that it decreases walkability (Table 7).

Table 8 summarizes the factors that increase students' walkability on campus, the factors that decrease it, and the factors that have no effect on it.

Discussion

Zhang et al. (2020) used a subjective evaluation approach based on questionnaires to assess campus walkability. King et al. (2020) based their study on the views of campus participants regarding walkability. A questionnaire survey was used in the study to measure participants' perceptions of the campus walkability.

Dörrzapf et al. (2019) and Zhang et al. (2020) showed that there is an inverse relationship between time and walkability, indicating that walkability decreases as time increases. Silitonga (2020) used walking distance, walking time, and walking speed to analyze walking behavior on the campus. He found

that the average walking speed is 1.40 meters per second, which is affected by age, gender, height, and weight.

The study used the time benchmarks acquired from the questionnaire survey to categorize walkability into three types: convenient walkability, when students can walk comfortably without feeling tired, up to 15 minutes; tolerable walkability, when students can walk despite feeling tired, from 15 to 30 minutes; and weary walkability, when students can no longer walk due to tiredness, after 30 minutes of walking. Most campus services are within tolerable walkability.

Various studies proposed various factors affecting walkability, such as density, land use mix, retail floor area, residential housing density, population density, roadway connectivity, and retail outlet density (Glazier et al., 2012). Other factors include street connectivity, destination accessibility, aesthetics, pedestrian facilities, residential density, and safety (Grasser et al., 2016; McCormack and Shiell, 2011; Zhang et al., 2020). The researchers categorized 29 factors into four groups: campus infrastructure factors, campus layout factors, context and services factors, and students' behavior factors, and each group has its own attributes.

Street features are one of the factors increasing walkability. Forsyth et al. (2008) indicated that the roadway pattern as well as the features of the built environment affect walkability.

Another aspect that influences walkability is the walking distance, which is affected by the proximity of facilities (Mohamaddan, 2010; Peachey and Baller, 2015). Researchers studied the effect of travel distance and walking time on walkability (Saghapour et al., 2017). The factors that influence walking time include gender, age, health, and leisure (Saghapour et al., 2017; Silitonga, 2020). It was found that building proximity, spatial connectivity, building permeability, and pedestrian pathway network decrease the distance between facilities and increase students' campus walkability.

Destination accessibility was proposed as a walkability index (McCormack and Shiell, 2011), and Grasser et al. (2016) used GIS-based approaches to measure walkability and analyze the spatial accessibility of a single facility or multiple facilities

Table 7. **Factors' impact**

Factors	Attributes	Increase walkability	No effect	Decrease walkability
Campus infrastructure	Street features	48.4	30.1	21.5
	Street furniture	68.8	24.7	6.5
	Street intersections	8.6	45.2	46.2
	Vehicle density	0	36.6	63.4
	Pollution and noise	0	32.3	67.7
	Car parks	37.6	45.2	17.2
	Public transit	16.1	35.5	48.4
Campus layout	Student density	24.7	41.9	33.3
	Building proximity	52.7	25.8	21.5
	Space connectivity	57.0	29.0	14.0
	Large university area	11.8	21.5	66.7
	Building orientation	30.1	45.2	24.7
	Building scale	28.0	52.7	19.4
	Building permeability	47.3	34.4	18.3
	Pedestrian pathway network	71.0	19.4	9.7
	Open spaces and green areas	69.9	19.4	10.8
Context and services	Destinations	52.7	40.9	6.5
	Activity type (dining, visiting the library, etc.)	59.1	34.4	6.5
	Building design	31.2	34.4	33.3
	Building facades	32.3	54.8	12.9
	Service diversity	52.7	37.6	9.7
	Place vitality	78.5	15.1	15.1
	Maintenance	57.0	21.5	21.5
Students' behavior	Safety	81.7	15.1	3.2
	Way-finding	69.9	25.8	4.3
	Walking alone	34.4	38.7	26.9
	Students walking or staying	41.9	44.1	14.0
	Walking with friends	74.2	25.8	0
	Hot or cold weather	0	22.6	77.4

Table 8. **Walkability factors' effect**

Factors increasing walkability	
Campus infrastructure	Street features, street furniture
Campus layout	Building proximity, space connectivity, building permeability, pedestrian pathway networks, open spaces and green areas
Context and services	Destinations, activity type (dining, visiting the library, etc.), service diversity, place vitality, and maintenance
Students' behavior	Safety, way-finding, and walking with friends
Factors having no effect	
Campus infrastructure	Car parks
Campus layout	Student density, building orientation, and building scale
Context and services	Building design and building facades
Students' behavior	Students walking or staying and walking alone
Factors decreasing walkability	
Campus infrastructure	Street intersections, vehicle density, pollution and noise, and public transit
Campus layout	Large university area
Context and services	-
Students' behavior	Hot or cold weather

(Grasser et al., 2016; Vale, 2015). Furthermore, it was found that the destination increased the willingness to walk.

Zhang et al. (2020) found that the variety, frequency, and distance that students travel to and from public facilities improved walkability. Moreover, the study found that activity type (dining, visiting the library, etc.), service diversity, place vitality, and maintenance increase walkability. Pedestrian facilities and diverse community facilities also affect walkability (Grasser et al., 2016; McCormack and Shiell, 2011; Taleai and Yameqani, 2018). The results conclude that street furniture and facilities increase students' campus walkability.

Urban features and green spaces are another two factors that affect walkability (Brownson et al., 2009; Dörrzapf et al., 2019; Krenn et al., 2015). The study showed that open spaces and green areas increased students' campus walkability, while street intersections, high vehicle density, and the availability of public transit on the university campus decreased walkability. Car parks had no effect on walkability.

Safety is one of the main factors that enhances students' campus walkability. That is congruent with the results of Azmi and Karim (2012), Dörrzapf et al. (2019), and Peachey and Baller (2015).

Several studies evaluated campus walkability in relation to students' physical activity (Zhang et al., 2020). Others focused on social and individual aspects (Reyer et al., 2014; Dörrzapf et al., 2019). The friendliness of a walkable environment affects walkability (Zhang et al., 2020), and familiarity increases comfort while walking (Azmi and Karim, 2012; Long et al., 2018). It was found that easy way-finding and walking with friends increase walkability.

Frank et al. (2010), Grasser et al. (2016), McCormack and Shiell (2011), and Peachey and Baller (2015) proposed a walkability index considering student density. The results found that the density of students increased walkability. Additionally, when students walk or gather in groups along pedestrian paths, this also increases walkability.

King et al. (2020) used a different method to assess campus walkability by combining campus participants' perceptions with environmental factors. Forsyth et al. (2008) listed over 200 factors that influence walkability, including attractions and aesthetics (Long et al., 2018; Dörrzapf et al., 2019). Researchers also used a walkability measurement metric based on block length, street connectivity, and facility layout (McCormack and Shiell, 2011; Zhang et al., 2020). It was found that building design, building orientation, building facades, and building scale have no effect on walkability.

Another method was used to assess walkability based on environmental conditions (Dörrzapf et al., 2019; King et al., 2020). The results showed that pollution, noise, and hot or cold weather decreased the students' willingness to walk.

Conclusion

This study examines several issues related to students' campus walkability, including the average frequency of the campus services use by students, and determines the benchmarks needed to classify students' campus walkability as well as students' campus walkability factors. The AABU University in Mafraq, Jordan, was selected as a case study.

The average frequency of using various facilities per week was grouped into high-frequency, medium-frequency, and low-frequency categories. The bus station has a high frequency of use as it is used more than five times a week. The engineering cafeteria has a medium frequency of use as it is used from one to four times per week, while other facilities have a low frequency of use.

The study used the time benchmarks acquired from the survey to categorize walkability into three groups: convenient walkability, tolerable walkability, and weary walkability. The time benchmarks include: walking for 15 minutes from the start, which is considered convenient since students can walk comfortably; from 15 to 30 minutes, which is tolerable walkability since students can walk even when they feel tired; and after 30 minutes, weary walkability, when students cannot walk anymore.

The study examines the effect of several factors on students' campus walkability. The factors were categorized into four groups: campus infrastructure factors, campus layout factors, context and service factors, and students' behavior factors.

The factors that increase students' campus walkability include street features, proximity of buildings, space connectivity, building permeability, pedestrian pathway network, open spaces and green areas, street furniture, destinations, activity type, service diversity, place vitality, maintenance, safety, way-finding, and walking with friends.

The factors that decrease students' campus walkability include street intersections, vehicle density, pollution and noise, public transit, large university areas, and hot or cold weather. The factors that have no effect on students' campus walkability include building design, student density, building orientation, building scale, car parks, students' walking or staying, building facades, and walking alone.

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ПОВЫШЕНИЕ ПЕШЕХОДНОЙ ДОСТУПНОСТИ ТЕРРИТОРИИ УНИВЕРСИТЕТА КАК ПОКАЗАТЕЛЬ УСТОЙЧИВОГО РАЗВИТИЯ

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Аннотация

Введение: В последнее время ходьба стала важным и экологичным способом передвижения для студентов университетов в их повседневной жизни. На пешеходную доступность студентов влияют характеристики и среда застройки кампуса. **Цель данного исследования** — определить временные ориентиры, необходимые для классификации пешеходной доступности территории университета, а также изучить факторы, влияющие на пешеходную доступность территории университета, которые включают четыре следующие группы: инфраструктура территории университета, планировка территории университета, среда и услуги, а также поведение студентов. **Методы:** Студентам инженерного факультета Университета Аль аль-Байт в Мафраке, Иордания, было предложено заполнить анкету. Для анализа данных и получения результатов использовалась программа SPSS. В соответствии с полученными **результатами** пешеходная доступность для обучающихся подразделяется на следующие категории: комфортная, приемлемая и утомляющая. Соответствующие факторы подразделяются на факторы, увеличивающие, уменьшающие и не оказывающие влияния на пешеходную доступность территории университета. Значимость исследования обусловлена изучением пешеходной доступности в связи с одним из основных способов передвижения по территории университета. Она считается важным компонентом устойчивого развития и используется при проектировании для определения доступности различных услуг, необходимых студентам университета.

Ключевые слова: устойчивое развитие; пешеходная доступность; поведение пешеходов; пешеходная доступность территории университета.