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Artículos científicos

La peatonabilidad desde la perspectiva sistémico-sustentable y la calidad de la accesibilidad radial del Parque Central de Ciudad Juárez, México

Pedestrianization from the systemic-sustainable perspective and the quality of radial accessibility of Parque Central in Juárez, México

A pedestre desde a perspectiva sistêmico-sustentável e a qualidade da acessibilidade radial do Parque Central de Ciudad Juárez, México

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Resumen

La peatonabilidad es una característica de las ciudades sustentables. En el caso de Ciudad Juárez, México, se tienen serios rezagos en infraestructura urbana y malas prácticas cívicas que afectan el traslado a pie de las personas hacia el espacio público. El objetivo de este trabajo es evaluar la accesibilidad radial tomando como referencia un parque urbano. La investigación adopta un método de observación directa en las rutas radiales considerando a un adulto sano. El análisis de los datos se basó en una visión sistémica de distinción entre la variabilidad aleatoria y la variabilidad especial con base en la distribución de Poisson y un posterior análisis de criticidad. El estudio se realizó en el entorno construido a un radio de 800 m del Parque Central ubicado en Ciudad Juárez. Se evaluaron seis rutas identificando y registrando los obstáculos fijos y no fijos que impedían o restringían el tránsito caminando. Los resultados revelaron que prevalecen cinco obstáculos de alta criticidad que afectan a la peatonabilidad y, por consiguiente, a la calidad de la accesibilidad radial del parque. Tres de estos obstáculos se asociaron con el estado de las aceras y los dos restantes con el estado de las calles. Se analizan escenarios de gestión para abordar esta problemática y se discute su relevancia. Finalmente, se concluye que el enfoque utilizado es pertinente para el estudio de la calidad de la accesibilidad radial del parque y se sugiere una agenda de investigación para futuros trabajos.

Palabras clave: caminabilidad, entorno construido, entropía urbana, parque urbano, sustentabilidad urbana.

Abstract

Pedestrianization is a key factor for sustainable cities. In the case of Ciudad Juarez, Mexico, there are serious shortcomings in urban infrastructure and poor civic practices that affect the mobility of people on foot to public space. The objective of this work is to evaluate radial accessibility taking an urban park as a reference. The research adopts a direct observation method on radial routes considering a healthy adult. The data analysis was based on a systemic view that distinguishes between random variability and assignable variability adopting Poisson distribution and a subsequent criticality analysis. The study was conducted in the built environment within an 800 m radius of Parque Central located in Juarez. Six routes were evaluated by identifying and recording fixed and non-fixed obstacles that impeded or restricted walking traffic. Results revealed the prevalence of five high criticality obstacles affecting pedestrian walkability and, consequently, the quality of radial accessibility of the park. Three of these obstacles were associated with the condition of the sidewalks and the remaining two with the condition of the streets. Management scenarios to address this issue are analyzed and their relevance is discussed. Finally, it is concluded that the approach used is relevant to the study of the quality of radial accessibility of the park and a research agenda for future work is suggested.

Keywords: walkability, built environment, urban entropy, urban park, urban sustainability.

Resumo

A caminhabilidade é uma característica das cidades sustentáveis. No caso de Ciudad Juárez, no México, há sérios atrasos na infraestrutura urbana e más práticas cívicas que afetam o deslocamento de pessoas para os espaços públicos a pé. O objetivo deste trabalho é avaliar a acessibilidade radial tomando como referência um parque urbano. A pesquisa adota um método de observação direta nas rotas radiais considerando um adulto saudável. A análise dos dados foi baseada em uma visão sistêmica de distinção entre variabilidade aleatória e variabilidade especial com base na distribuição de Poisson e posterior análise de criticidade. O estudo foi realizado no ambiente construído em um raio de 800 m do Central Park localizado em Ciudad Juárez. Seis rotas foram avaliadas identificando e registrando obstáculos fixos e não fixos que impediam ou restringiam o tráfego de pedestres. Os resultados revelaram que prevalecem cinco obstáculos altamente críticos que afetam os pedestres e, consequentemente, a qualidade da acessibilidade radial do parque. Três desses obstáculos estavam associados à condição das calçadas e os dois restantes à condição das ruas. Cenários de gestão para resolver este problema são analisados e sua relevância é discutida. Por fim, conclui-se que a abordagem utilizada é relevante para o estudo da qualidade da acessibilidade radial do parque e sugere-se uma agenda de pesquisa para trabalhos futuros.

Palavras-chave: caminhabilidade, ambiente construído, entropia urbana, parque urbano, sustentabilidade urbana.

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Introduction

Cities are open entropic systems that have an intense interaction with their environment: from there they obtain materials and energy and, at the same time, much of the waste and degraded energy they generate ends up there (Kennedy, Pincetl and Bunje, 2011). If urban systems are left unmanaged, the level of entropy will increase disproportionately (Pelorosso, Gobattoni and Leone, 2017). Urban entropy is a complex phenomenon that transcends the multidisciplinary field, although it is widely accepted that the urban sustainability approach is adequate for its control and reduction (Wu, 2014). One of the main factors in the search for urban sustainability is the walkability attribute, that is, the set of conditions that allow transit in the urban environment in a non-motorized way, according to the capabilities of those who transit it. (Florindo et al., 2019; Forsyth, 2015; Cubukcu, 2013). This type of individual transportation is sustainable because it reduces the use of fossil fuels and improves health, in addition to opening a door of opportunity to experience the city (Cubukcu, 2013).

In the study of walkability, it is common to consider a reference point (for example: shopping center, urban park or health center) from which one or more paths are studied in a range of lengths from 500 m to 1500 m, feasible distance of be traveled on foot in a time of 10-15 min (Asadi-Shekari, Moeinaddini and Zaly, 2013; Duncan, Aldstadt, Whalen, Melly and Gortmaker, 2011). When it comes specifically to green spaces, including urban parks, it has been shown that better levels of walkability are associated with more frequent and intensive use of these spaces (Zuniga et al., 2019). Radial accessibility to recreation spaces, mainly urban parks, must include an environment free of difficulties that prevent walking towards them. A well-known parameter is presented from the "8-80 space" metaphor, which refers to a public space being accessible if both an eight-year-old infant and an 80-year-old adult can access it on foot without obstacles that prevent them. (Peñalosa, 2018).

The most referred dimensions of walkability are: Connectivity, Convenience, Comfort, Coexistence and Conspicuity, to which Coexistence and Commitment are usually added, referred to as the 7Cs (Moura, Cambra and Gonçalves, 2017) (table 1). Its study is approached from the disciplines of engineering or architecture, considering approaches based on direct observation (audit and verification lists, inventories, service levels, assessment scales) and other tools such as surveys or interviews, in addition to the use of geographic information systems (GIS) (Moura et al., 2017; Shashank and Schuurman, 2019; Talavera and Soria, 2015; Telega, Telega and Bieda, 2021).

A constant in walkability research is its transversal temporality: the built environment is studied in a single measurement and the state or degree of walkability of the studied space is reported, depending on the approach adopted (Maghelal and Capp, 2011). Although this approach is practical and pertinent, it was not possible to identify studies that consider the systemic nature of the city and that recognize that urban development, rather than an isolated action, is a process that maintains continuity and is configured in accordance with the execution of the actions in the cities from different visions and ideologies, with intense interaction, which outline the profile of the city and influence its democratic practices (Pinson and Morel, 2016). That is: the city is a system and as such it is possible to place it in the epistemological niche of the general theory of systems, following its principles and characteristics. (von Bertalanffy, 1976).

Tabla 1. Dimensiones del concepto *caminabilidad*

Dimensión	Descripción
Conectividad	Al brindar opciones directas y cortas, los peatones se integran a la red de orígenes y destinos.
Conveniencia	Caminar se vuelve eficiente (en tiempo, dinero y espacio) en relación con otros tipos de transporte.
Confortabilidad	Los atributos del trayecto se adecuan a las capacidades y habilidades de todos los tipos de peatones para facilitar la experiencia del traslado individual.
Convivencia	El grado de interacción con otras personas que caminan. El entorno natural y construido en el que se llevan a cabo las actividades y la recreación.
Conspicuidad	Las rutas peatonales son claras, coherentes y están bien señalizadas.
Coexistencia	El traslado individual coexiste en armonía con otras formas de traslado, sin experimentar sensaciones de inferioridad.
Compromiso	Existe evidencia de involucramiento y responsabilidad de las autoridades locales con los peatones.

Fuente: Moura *et al*. (2017, p. 284)

The open city system is susceptible to being affected by internal and external factors that influence its performance towards the achievement of its objectives, which in the case of sustainability is to satisfy current needs without compromising future needs (Contreras and Aguilar, 2012). . Then, the state of the system becomes a relevant condition to explain its performance at a given moment in relation to an output or quality (output). This has to do with the configuration of the urban process, the one that transforms tangible and intangible inputs (input) into output.

The state of the built urban environment is a determining factor in walkability (Zuniga et al., 2017); thus, its management is pertinent because it can be affected by the conditions inherent to the urban process (random conditions or causes) and by special causes (external or assignable causes). It is clear that the phenomenon of variation is present in the urban process and that it can be separated into random and assignable, that is, it is possible to use statistical process control (SPC) tools in its study (Shewhart, 1986), although not necessarily as longitudinal monitoring techniques, but located in the transversal nature of this typology of urban studies, the CEP can become a powerful diagnostic tool that provides direction to management.

With the foregoing, it is necessary to highlight that the monitoring of the urban process, in terms of the state of the built environment to favor walkability, is a very slow process in its evolution that cannot be conducted with the same frequency with which it is carried out. in industrial processes (every hour or every shift, for example) and that it would be very ambitious to cover all seven dimensions of walkability with this approach. The most important of these is the one related to comfort, that is, to the attributes of a site or route and how these allow individual transit to a destination for different groups of pedestrians (Moura et al., 2017; Rahaman, Lourenço and Viegas, 2012).

Around this dimension the pedestrian concept is grouped, which refers to the act of moving individually, independently or assisted, but not motorized, from an origin to a destination on a journey in a city and that is directly related to the built environment (Forsyth, 2015; Hussein, 2018; Maghelal and Capp, 2011).

Another quality of utmost importance is that which refers to radial accessibility, understood as the ability to move autonomously, individually to a destination within 500 m to 1500 m, without obstacles that hinder or prevent it, in addition to guaranteeing adequate conditions of security and comfort, while seeking the inclusion of various social groups (Zuniga *et al*., 2019; Zuniga *et al*., 2017; Serrano, Jaramillo, Campos y Galindo, 2013; Tal y Handy, 2012).

Problem Statement

Radio accessibility is considered a fundamental element in the sustainability of cities, since it makes it possible for diverse groups to meet, which in turn reinforces citizen cohesion, equity and other social factors, in addition to promoting exercise and promotes health (Cambra, 2012; Cubukcu, 2013; Subirats, 2016; Zuniga et al., 2017). The quality of radial accessibility is a function to a great extent of walkability and this depends on the state of the built environment.

In Ciudad Juárez, there are serious lags in urban infrastructure and poor civic practices that affect the movement of people on foot to public space. In the case of Parque Central, the quality of radial accessibility in its radius of influence and the pertinent management strategies to improve it are unknown. Based on the above, the objective of this work is to evaluate radial accessibility taking an urban park as a reference.

Method

The Central Park of Ciudad Juárez, Mexico, which annually receives between 1,100,000-1,300,000 visitors, was the site where the study was carried out. The space comprises an area of 20 ha of green areas and bodies of water. The park is located at 31.73º north latitude and 106.48º west longitude (figure 1). Its offer includes recreation and exercise facilities, corridors of vegetation, a botanical garden and various squares for passive or relaxation activities. The park has an artificial lake that prints landscape beauty and promotes diversity; the lake is home to fish (carp, trout and catfish), two species of turtles, as well as being used by birds of various species, mainly ducks. One of its biggest attractions is a male giraffe, which has become the symbol of the park.

To evaluate radial accessibility, six routes were chosen at random in a radius of 800 m around the park (figure 2), which were adjusted to the logic of the route towards the park, that is, looking for the shortest route and without unnecessary detours; the travel time of a certain route is estimated between 10-15 min.

Figura 1. Aspectos del Parque Central en Ciudad Juárez, México

Fuente. Elaboración propia

Figura 2. Seis rutas de acceso peatonal al Parque Central en un radio de 800 m

Fuente: Elaboración propia con base en Google Earth

The approach was to study the state of the built environment related to pedestrians: knowing the context of urban facilities focusing on those negative aspects that prevented or limited the process of arrival of users to the park, an exercise rarely seen in the literature, whose main references are government regulations, which regularly focus on people with motor disabilities (Secretaria de Desarrollo Urbano y Vivienda [Seduvi], 2016). To this end, it was necessary to contextualize the study in the reality of Ciudad Juárez, where, despite an ordinance being in force, there are marked lags in urban infrastructure and paving (Municipal Research and Planning Institute [IMIP], 2020), as well as bad practices civic (lack of respect for streets and sidewalks) (Sánchez, March 20, 2019). With the above, an evaluation instrument agreed by experts was developed to record the state of the built environment in relation to pedestrians, by means of which a division was established between fixed and mobile obstacles (table 2). An adult in normal physical conditions traveled the six routes and through direct observation and counting recognized the obstacles that she encountered on each of the six routes and recorded them on the instrument. For each obstacle a photographic memory was kept. At this point, it is pertinent to clarify that the six routes correspond to areas of comparable socioeconomic characteristics, without significant differences between them. (IMIP, 2021).

Tabla 2. Elementos de evaluación de la accesibilidad radial a 800 m del Parque Central

Obstáculos fijos		Obstáculos móviles	
Acera	Faltante	Acera	Bloqueada por automóvil
	En mal estado		Bloqueada por material
	Bloqueada por elemento fijo		Bloqueada por anuncios
	Demasiado estrecha		Bloqueada por mercancía
Rampa	Faltante	Comercio	Puesto comercial en acera
	En mal estado		Puesto comercial en calle
	Bloqueada por elemento fijo		Mercado o vehículo comercial
Pavimento	Faltante		Talleres mecánicos
	En mal estado	Vehículos	Bloqueando calle
	Suelto o baches		En doble fila
Horadación	Hoyo en acera		Estacionados en batería
	Hoyo en calle		Abandonados
	Zanja		Vehículo de carga presente
Discontinuidad en el trayecto	Desvío obligado de ruta lógica	Diversos	Desechos orgánicos de animales
	Puesto de seguridad privada		Postes, árboles o ramas tiradas
	Calle cerrada por seguridad		Contenedores de basura, macetas
	Calle cerrada (otro motivo)		Otros
	Rejas o cerco salvable		
	Tope reductor de velocidad		
	Dren, acequia o arroyo		
Avenida	Avenida principal		
	Puente o paso peatonal		
Diversos	Otros		

Fuente: Elaboración propia

In this case, the probability that an obstacle is present on a given path depends on the length of the route traveled. Likewise, when considering six segments of equal magnitude in the same urban environment, there is a uniform study unit. However, the obstacles appear independently among the routes studied. The above considerations are characteristic of the phenomena that follow the Poisson distribution (Walpole, Myers, Myers and Ye, 2012). Therefore, the probability of encountering k obstacles on a given route is given by:

$$p(k,\lambda) = \frac{e^{-\lambda}\lambda^{k}}{k!} \quad k = 0,1,2,\ldots \qquad (1)$$

In that formula λ is the parameter of the Poisson distribution. Then, the circle with a radius of 800 m is the system to be studied and the route R_i is the uniform entity that is affected by the natural or random variation, inherent to the universe of obstacles comprised within the circle, and the special or relative variation, attributable to the specific obstacles of the route *Ri*:

$$S_{t_i} = S_c + S_{R_i} \quad i = 1,2,,,,,,6 \qquad (2)$$

In formula 2, on the other hand:

- S_{ti} is the total variation of the path *i*.
- S_c is the random variation of the considered region (circle with radius of 800 m).
- S_{Ri} is the special variation attributable to the path *i*.

Since in the Poisson distribution $E(x) = \lambda$ and $V(x) = \lambda$, the range of S_c is:

$$S_c = \lambda \pm 3\sqrt{\lambda} \qquad (3)$$

This scheme revealed which routes presented a number of obstacles greater than the range of random variation, which allowed knowing the type of obstacles specific to each route.

Results

The results of the routes in terms of the frequency of obstacles fit a Poisson distribution ($p < 0.320$) and are shown in Table 3. Routes one, two and three are shown in Figure 3 and the Routes four, five and six are shown in figure 4. The most frequent fixed obstacles are: missing sidewalk, sidewalk in poor condition, loose pavement or potholes, sidewalk blocked by fixed element and speed bump. Three of them are related to sidewalks, a crucial element for radial accessibility (Landin, February 23, 2016). The evaluation begins by analyzing the frequency with which they occur on each route; later, and in order to discriminate between the importance of fixed obstacles for radial accessibility, an ordinal weighting of criticality was incorporated into the analysis. This analysis made it possible to identify how accessible each route is for walking to the park.

Figure 5 shows the results of the processing of the findings through a graph based on the Poisson distribution, according to equation 1. The value of the parameter λ it was estimated at 1.15 obstacles/route. Then, from equation 3, the lower and upper limits of the random variation inherent in the studied region are:

$$S_C \quad = \lambda \pm 3\sqrt{\lambda} = 1.15 \pm 3\sqrt{1.15} = (0, 4.37)$$

Tabla 3. Frecuencia de inconvenientes y obstáculos fijos y no fijos en el radio de 800 m del Parque Central

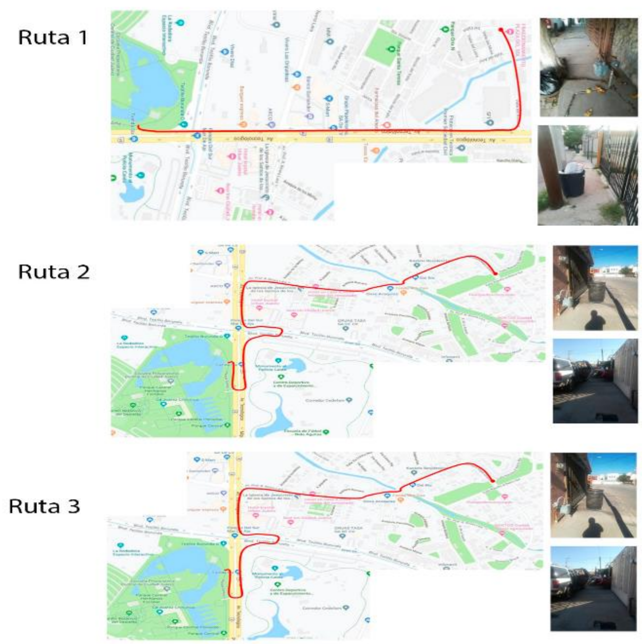
Obstáculos o dificultades fijos		Ruta						Total	NI
		1	2	3	4	5	6		
Acera	Faltante	2	2	12	2	8	3	29	1
	En mal estado	3	0	5	3	4	1	16	2
	Bloqueada por elemento fijo	1	1	2	1	5	3	13	4
	Demasiado estrecha	1	1	0	1	1	1	5	9
Rampa	Faltante	0	1	2	1	2	1	7	8
	En mal estado	1	2	1	1	1	1	7	8
	Rampa bloqueada por elemento fijo	0	0	0	0	0	0	0	19
Pavimento	Faltante	0	1	2	0	1	0	4	10
	En mal estado	0	2	1	0	0	0	3	12
	Suelto o baches	0	0	0	8	2	5	15	3
Horadación	Hoyo en acera	1	3	4	0	0	0	8	7
	Hoyo en acera	2	1	1	1	0	5	10	6
	Zanja	0	0	0	0	0	1	1	16
Discontinuidad en el trayecto	Puesto de seguridad privada	0	1	0	0	0	0	1	16
	Calle cerrada por seguridad	1	2	0	0	0	0	3	12

	Calle cerrada (otro motivo fijo)	0	0	0	0	0	0	0	19
	Rejas o cerco salvable	0	0	0	0	2	0	2	15
	Tope reductor de velocidad	2	9	2	0	0	0	13	4
	Dren, acequia o arroyo	0	1	0	0	0	0	1	16
	Puente peatonal	0	2	0	1	0	0	3	12
	Avenida principal	1	1	1	0	0	1	4	10
	Total	15	30	33	19	26	22	145	
Obstáculos o dificultades no fijos									
	Acera bloqueada por automóvil	0	2	0	2	0	0	4	2
	Acera bloqueada por material de construcción	1	1	0	0	0	0	2	4
	Acera bloqueada por anuncios	0	0	0	1	0	1	2	4
	Desechos orgánicos	1	0	0	0	0	0	1	6
	Mercancía o muebles en la acera	0	0	0	1	0	0	1	6
	Puestos de comida movibles en acera	0	0	2	0	1	0	3	3
	Otros bloqueos de acera (contenedores de basura, macetas)	3	12	4	12	6	5	42	1
	Automóviles bloqueando calle	0	0	0	0	0	0	0	7
	Mercados o vehículos comerciales	0	0	0	0	0	0	0	7
	Vehículos estacionados en doble fila	0	0	0	0	0	0	0	7

	Vehículos estacionados en batería	0	0	0	0	0	0	0	7
	Talleres mecánicos o vehículos en reparación	0	0	0	0	0	0	0	7
	Vehículos abandonados	0	0	0	0	0	0	0	7
	Cajas de tráiler	0	0	0	0	0	0	0	7
	Postes o árboles tirados	0	0	0	0	0	0	0	7
	Total	5	15	6	16	7	6	55	
Nota: solo se muestran los obstáculos encontrados en alguna ruta. NI = Nivel de importancia									

Fuente: Elaboración propia

Figura 3. Rutas uno, dos y tres y ejemplos de algunos obstáculos



Fuente: Elaboración propia

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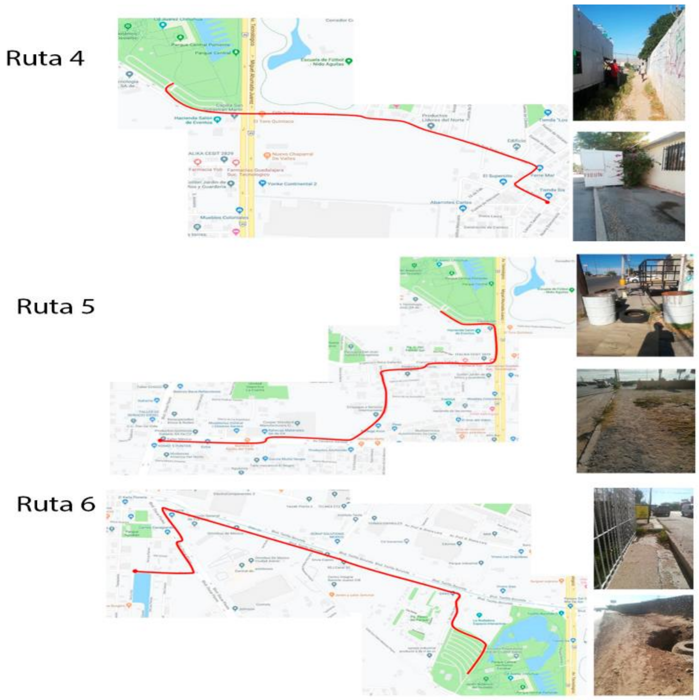
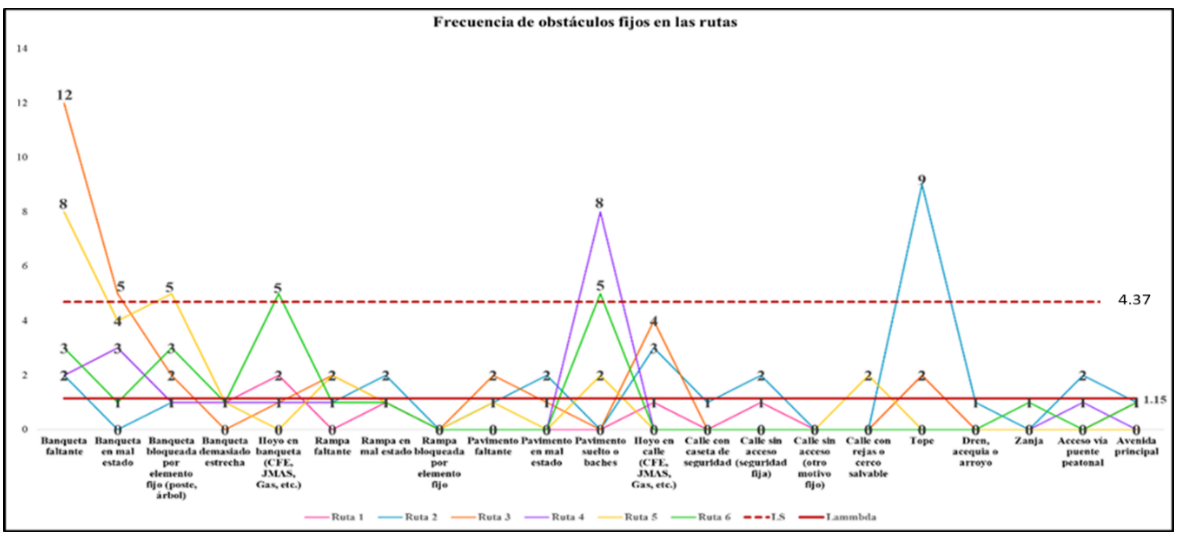
Figura 4. Rutas cuatro, cinco y seis y ejemplos de algunos obstáculos



Fuente: Elaboración propia

Figura 5. Frecuencia de obstáculos fijos en las rutas



Fuente: Elaboración propia

The value of the upper limit of S_c stands at 4.37 hurdles. The frequencies of those obstacles that exceed this limit and that are attributable precisely to the route where they occurred stand out. Thus, in route one, frequencies lower than the border with random variation are observed, which suggests that a dominant fixed obstacle is not present in this route. For its part, on route two the fixed obstacle "Speed bump" is specifically attributable to this route, beyond random variation. The same thing happens with the obstacles "missing sidewalk" and "sidewalk in poor condition", which are specific to route 3. While the fixed obstacle “loose pavement or potholes” stands out in route 4. The obstacles “sidewalk missing” and “sidewalk blocked” are attributable to route 5. Lastly, route 6 fixed obstacles “hole in sidewalk” and “loose pavement or potholes” are attributable.

The frequency with which fixed obstacles appear is useful to identify those that are more common in each path studied. However, not all fixed obstacles are of the same importance: some are insurmountable, others are unavoidable but surmountable, and others can be avoided along the way. Fixed obstacles were penalized based on a weighting factor (w = 5, 3, 1), where 5 is very critical, 3 is important, and 1 is non-critical and less important. The results are shown in table 4 and table 5; the graphical representation in figure 6.

Tabla 4. Obstáculos fijos atribuibles a las rutas consideradas en el radio de 800 m del Parque Central

Obstáculos o dificultades	Ruta					
Fijos	1	2	3	4	5	6
Acera faltante	2	2		2		3
Acera en mal estado	3	0		3	4	1
Acera bloqueada por elemento fijo (poste, árbol)	1	1	2	1		3
Acera demasiado estrecha	1	1	0	1	1	1
Hoyo en acera (CFE, JMAS, gas, etc.)	2	1	1	1	0	
Rampa faltante	0	1	2	1	2	1
Rampa en mal estado	1	2	1	1	1	1
Rampa bloqueada por elemento fijo	0	0	0	0	0	0
Pavimento faltante	0	1	2	0	1	0
Pavimento en mal estado	0	2	1	0	0	0
Pavimento suelto o baches	0	0	0		2	
Hoyo en calle (CFE, JMAS, gas, etc.)	1	3	4	0	0	0
Calle con caseta de seguridad	0	1	0	0	0	0
Calle sin acceso (seguridad fija)	1	2	0	0	0	0
Calle sin acceso (otro motivo fijo)	0	0	0	0	0	0
Calle con rejas o cerco salvable	0	0	0	0	2	0
Tope	2		2	0	0	0
Dren, acequia o arroyo	0	1	0	0	0	0
Zanja	0	0	0	0	0	1
Acceso vía puente peatonal	0	2	0	1	0	0
Avenida principal	1	1	1	0	0	1
CFE = Comisión Federal de Electricidad JMAS = Junta Municipal de Agua y Saneamiento						

Fuente: Elaboración propia

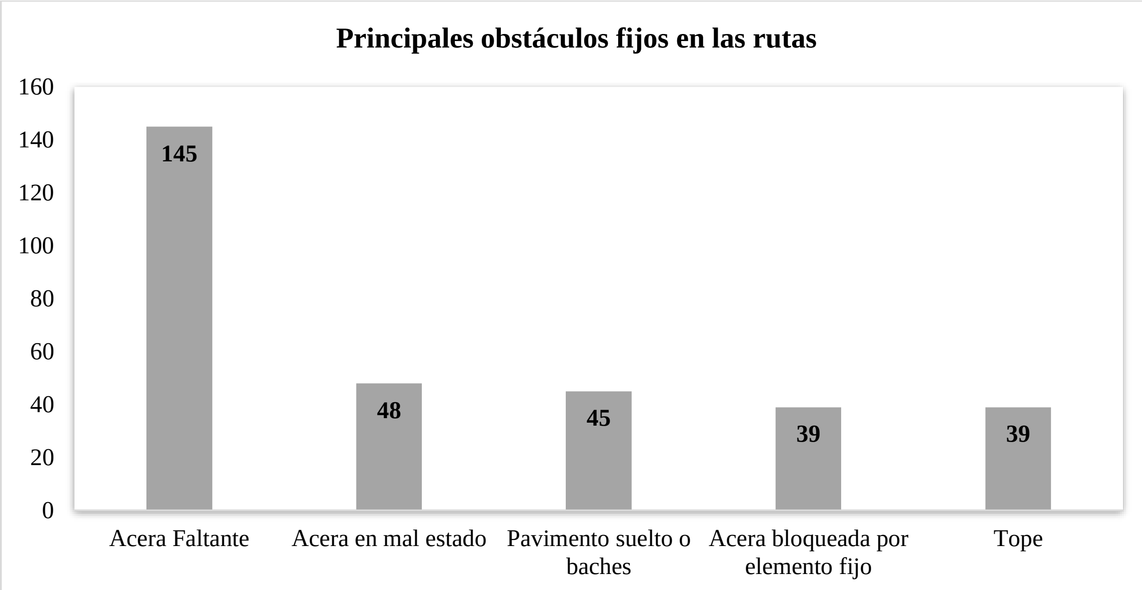
Tabla 5. Penalización de obstáculos fijos en las rutas consideradas

Obstáculos o dificultades Fijos	*W*	Ruta 1	2	3	4	5	6	Total	NI
Acera faltante	5	10	10	60	10	40	15	145	1
Acera en mal estado	3	9	0	15	9	12	3	48	2
Acera bloqueada por elemento fijo	3	3	3	6	3	15	9	39	4
Acera demasiado estrecha	3	3	3	0	3	3	3	15	10
Hoyo en acera (CFE, JMAS, gas, etc.)	3	6	3	3	3	0	15	30	7
Rampa faltante	5	0	5	10	5	10	5	35	6
Rampa en mal estado	3	3	6	3	3	3	3	21	8
Rampa bloqueada por elemento fijo	3	0	0	0	0	0	0	0	20
Pavimento faltante	5	0	5	10	0	5	0	20	9
Pavimento en mal estado	3	0	6	3	0	0	0	9	13
Pavimento suelto o baches	3	0	0	0	24	6	15	45	3
Hoyo en calle (CFE, JMAS, gas, etc.)	1	1	3	4	0	0	0	8	15
Calle con caseta de seguridad	1	0	1	0	0	0	0	1	19
Calle sin acceso (seguridad fija)	5	5	10	0	0	0	0	15	10
Calle sin acceso (otro motivo fijo)	5	0	0	0	0	0	0	0	20
Calle con rejas o cerco salvable	1	0	1	0	0	2	0	3	16
Tope	3	6	27	6	0	0	0	39	4
Dren, acequia o arroyo	3	0	3	0	0	0	0	3	16
Zanja	3	0	0	0	0	0	3	3	16
Acceso vía puente peatonal	3	0	6	0	3	0	0	9	13
Avenida principal	3	3	3	3	0	0	3	12	12
Total		49	95	123	63	96	74	500	

w = Factor de ponderación
NI = Nivel de importancia

Fuente: Elaboración propia

Figura 6. Principales obstáculos de nivel crítico en las rutas



Fuente: Elaboración propia

Given that the parametric analysis of variance (ANOVA) assumptions are not met, the Kruskal-Wallis Anova was adopted with the Holm-Bonferroni post hoc test, both weighting the routes and the type of fixed obstacle, which was significant. ($p < 0.000$). In the case of the routes, significant differences were found in the total number of penalties ($p < 0.001$), which resulted in the formation of four homogeneity subsets. The first set is made up of route one, with the least amount of penalty. The second group is made up of routes six, two and four, which do not present significant differences between them and which also have lower amounts of penalties. In the third group is route five with a significantly higher penalty amount than the previous ones. Finally, route three makes up the fourth group and is distinguished by having a significantly higher penalty amount than the rest of the routes.

From the perspective of the type of fixed obstacle, two relevant homogeneity groups were found ($p < 0.000$). In the first group, “missing sidewalk” contributes significantly to the largest penalty amount: it ranks first. In the other homogeneous group, the categories: “sidewalk in poor condition”, “loose pavement or potholes”, “sidewalk blocked by a fixed element and buffer” are located from second to fourth place, respectively, tied for fourth place for these last two. The other types of obstacles are less relevant to this analysis.

The moving obstacles along the way are circumstantial. Most are due to errors, omissions, breaches of local regulations or simply bad citizen habits. However, for purposes of accessing the park, they are factors that have a negative impact. By far more than 10 times in relation to the second place, the category “other sidewalk blockages” (which includes mobile elements, such as non-fixed flower pots and garbage containers, mainly) is positioned in first place. Far behind are “sidewalk blocked by car” and “mobile sidewalk food stall.”

Once the main obstacles and their criticality have been identified, it is pertinent to remember that local governments usually have diagnosed the problems within their sphere of competence. The constant that prevents its solution lies in budget restrictions, especially in terms of urban green spaces and their surroundings (Aalbers, Kamphorst and Langers, 2019; Jansson, Vogel, Fors and Randrup, 2019; Sainz and Martinez, 2021). In this case, the local authority of Ciudad Juárez has more at hand the intervention in the fixed obstacles and seems to have at least three alternatives in sight to improve the accessibility of the park:

a) The first would be to improve radial accessibility in general, which in itself would exceed the budgetary capacity of the municipality, since the city suffers from systemic problems of degradation of the built environment and bad citizen practices that would take time to reverse (IMIP, 2021; Sanchez, March 20, 2019).

b) The second alternative would be to bring all the obstacles with frequencies higher than four precisely to this level and reach a systemic condition of walkability for all the routes; however, this course of action seems to lack common sense, since it would be nonsense, for example, to repair a pothole (of the five that were found) simply to comply with this condition.

c) The third alternative would be to repair or remedy the five categories of obstacles that were most critical; this alternative would be focused and would not require a larger or extraordinary budget item.

Table 6 summarizes the scenarios available to the municipal authority and how the statistical analysis would change if they were carried out.

Tabla 6. Escenarios de gestión de la calidad de la accesibilidad radial del Parque Central

Alternativa	Promedio de obstáculos (λ)	Límite de variación aleatoria	Puntos de penalización	Diferencia con la alternativa original	Comentario
No hacer nada, estado actual.	1.15	4.37	500	Redundante	Peatonabilidad comprometida, baja calidad de accesibilidad radial.
Llevar los obstáculos más críticos a una frecuencia de cuatro.	0.952	3.88	401	Obstáculos: n. s. Penalización: n. s.	Peatonabilidad comprometida, baja calidad de accesibilidad radial. La mejora es marginal, no significativa.
Reparar por completo los cinco obstáculos más críticos.	0.698	3.21	289	Obstáculos: $p < 0.019$ Penalización: $p < 0.026$	Mejora significativa de la peatonabilidad, mejora de la calidad de la accesibilidad radial.
n. s. = No significativo					

Fuente: Elaboración propia

For the third scenario, the Kruskal-Wallis test between routes and obstacles was not significant (p < 0.410 and p < 0.214, respectively), which suggests that a particular route or obstacle would not stand out in the considered radius. If the municipal authority concentrates on repairing or correcting the five fixed obstacles derived from the statistical and criticality analysis, pedestrians would be significantly improved and, consequently, the quality of the radial accessibility of the park. It is necessary to clarify that the economic evaluation of the alternatives presented is beyond the purpose of this article.

Discussion

Poisson's statistical analysis, considering that the city is a system and that the built environment, which to a great extent defines walkability, can be studied as a process in which it is feasible to separate the conditions inherent to the dynamics of the city itself (random variation) of the causes attributable to certain routes (special or attributable variation), revealed effective management strategies for the municipal government.

The improvement in the quality of accessibility of the Central Park is manifested by combining the statistical analysis and the criticality analysis, which allows focusing on the relevant factors, in this case the obstacles that most negatively affect pedestrians. The radius of 800 m that was considered for the analysis is not a network of a diversity of routes, since the park is located, on the one hand, at the intersection of two main avenues of the city; and on the other, the routes that move away from the logical access paths to the park do not define its radial accessibility. That is, the routes considered in this study, or segments of these, would be the ones that the vast majority of people would subsequently use to walk to the park within the study radius.

Of the great diversity of obstacles that limit pedestrians and affect the quality of radial accessibility, three refer to sidewalks, an essential element, not only for pedestrians, but for urban sustainability as a whole and even for democracy itself. , as some research has highlighted (Gunn, Lee, Geelhoed, Shiell, and Giles, 2014; Landin, February 23, 2016; Osama and Sayed, 2017; Vallejo, Cantillo, and Rodriguez, 2020). So, the approach adopted in this work reiterates the importance of sidewalks, especially for vulnerable groups of the population, in addition to providing direction to government management towards their improvement. (Duan, Wagner, Zhang, Wulff y Brehm, 2018; Guo *et al*., 2019).

On the same topic, the current poor condition of the sidewalks and the non-fixed obstacles present force people to walk on the streets. In this sense, the two remaining critical obstacles that were also revealed from the analysis are manageable without incurring excessive expense for the authority. Thus, loose pavement and potholes are likely to be repaired as part of the city's routine patching program. On the other hand, speed bumps are the cause of mechanical failures and vehicle congestion on the streets; It is common for the reducing caps to be placed by the neighbors without complying with the municipal ordinance (Juárez, 2021). These obstacles can be removed and in their place signage and temporary road surveillance can be placed while motorists adhere to the regulations and the new conditions.

Regarding non-fixed obstacles, it is a recurring problem in the city (Sosa, 2015). In this sense, civic education is a fundamental factor in convincing citizens to respect sidewalks and streets, so that the free movement of people on foot is allowed. In this regard, the municipal government maintains an aggressive campaign to make good use of the sidewalks (Sánchez, March 20, 2019; El Diario de Juárez, April 13, 2019), we can only hope that these efforts continue and that each time there is more citizen awareness about the importance and benefits of walking around the city with obstacle-free sidewalks.

In general terms, this approach has the strength that the analysis is simple and the results are easily applicable in areas where the built environment can be identified and recorded within a walkable radius. Another advantage is that it provides a profile of criticality that makes it possible to recognize more important obstacles and focus municipal management efforts on the most relevant aspects that affect pedestrians. On the other hand, it is perhaps less relevant for the study of entire urban polygons or very long routes, outside the walking range of 800 m. For such approaches, GIS, official databases, or smartphone apps may be more suitable. (Telega *et al*., 2021; Yun, Zegras y Palencia, 2019).

The results found allowed to identify that the developed resources are insufficient or inadequate management, the conservation status of the built environment is diminished, the urban infrastructure is damaged and the population is harmed by this degradation; this degree of disorder is directly associated with the decrease in urban sustainability (Fistola, Gargiulo and La Rocca, 2020).

In the theme of exclusivity and accessibility of the park, it was found that the characteristics meet the needs of the urban park to be inclusive and accessible as a meeting and interaction territory that fosters diversity, social cohesion and promotes physical and mental health. , while strengthening the sustainability of the city (Grilli, Mohan and Curtis, 2020; Shashank and Schuurman, 2019). The results reveal that the dynamics of the urban process in terms of pedestrians is slow. And in this sense, the literature includes a set of case studies with cross-sectional temporality and with different techniques in which the importance of walkability is highlighted. (Humberto *et al*., 2019; Maghelal y Capp, 2011; Shashank y Schuurman, 2019).

Conclusions

In the context of its systemic and entropic nature, the city processes resources and energy, in addition to requiring management actions to maintain its functionality and stop its deterioration. It is concluded that the study reveals the existence of insufficient resources due to inadequate management. Derived from the above, the state of conservation of the built environment is diminished, the urban infrastructure is damaged and the population is harmed by this degradation.

Therefore, it is concluded that the proper management of the built environment is essential to allow the movement of people on foot (pedestrianism) within the radius of influence of the park, so this urban approach defined that the quality of the radial accessibility of a public space it is weak if there is no management that considers it a priority. In addition, the existing conditions at the time of the study were evidenced, which highlights the importance of this research and its immediate contributions to the existing problem.

The dynamics of the urban process in terms of pedestrians found revealed that it is slow. Consequently, the study concludes that the prevailing problem contributes in its gestation to the few investigations that consider the systemic condition of the built environment in the area of influence of an urban park and, therefore, contributes to the availability of discussion elements of direct effects on access to large-scale urban parks. The foregoing leads to the conclusion that this work and the approach of the systemic vision and incorporation of the innovative perspective of analysis, not only revealed the critical factors that affect the quality of the radial accessibility of the Central Park, but also revealed lines of effective management action for the municipal government. Therefore, it is concluded that the CEP approach, despite being a longitudinal monitoring technique, is pertinent to identify the state of pedestrians and evaluate the quality of radial accessibility to a public space in a transverse temporality exercise, for what its use is recommended.

Contributions to future lines of research

Finally, it is recommended to study the use of smart applications, georeferenced in real time, or at least with a short time delay (Guo et al., 2019; Moura et al., 2017; Telega et al., 2021). The foregoing would allow a pedestrian to visualize from his mobile device the most accessible route to reach the park, or anticipate eventualities along the way. This study can be complemented with a longitudinal investigation that shows the progress or degradation of the urban process in relation to the built environment, which for now constitutes a large gap in the literature, at least in Latin America. It is also recommended to study possible governance models to improve pedestrians, the quality of radial accessibility and the quality of urban green space in general (Sainz and Martinez, 2021). Citizen participation, in conjunction with the municipal authority, is perhaps the best long-term management strategy to increase pedestrians in the Central Park's area of influence and improve the quality of radial accessibility, reinforcing environmental, social and economic offered by the park.

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