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Walkable city and universal design in theory and practice in Poland

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Abstract. Understanding the city as a whole, its functioning, and needs of its inhabitants is currently becoming an important issue. Solutions introduced in cities based on the principles of the concept of walkable city and universal design are becoming more and more popular around the globe. Both topics have been so far discussed separately, although due to the requirements of social life and introduction of new legal regulations, they should be analysed together. The objective of the paper is to examine the impact of the design concepts of walkable city and universal design on the practical aspects of life of people with disabilities in selected cities, with particular consideration of obstacles existing in public spaces. The main contribution of this study is twofold. In the methodological aspect, a synthetic index was developed based on the 'Ten Steps of Walkability'. In practical terms, it was analysed from both the spatial aspect using UD principles (field inventory) and social perspective (semi-structured interviews with experts and a questionnaire survey). As a result, a mental map was developed, presenting obstacles and barriers in public spaces and in buildings relevant for people with and without disabilities (hearing, movement, and visual impairments). The results can be used for universal design worldwide to improve the accessibility of walkable spaces for people with special needs.

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Contents:

1. Introduction

Understanding the city as a whole, its functioning, and the needs of its inhabitants is becoming an increasingly important issue. The related research adopts the basic unit constituting a person living and developing in the urban space. It is aimed at the search for design solutions and concepts that would make the city friendly and good to live in. It concerns different spheres of human life in the city. This study focuses on two of such spheres, namely walkable city (Southworth, 2005; Frank et al., 2006; Speck, 2012; Forsyth, 2015) and universal design (Mace, 1985; Kaletsch, 2009; Gawron, 2015).

According to Gehl, the forerunner of the idea of a 'city for people', "walking is first and foremost a type of transportation, a way to get around, but it also provides an informal and uncomplicated possibility for being present in the public environment." (Gehl, 2011:133). This is closely related to the issue of creating an accessible and pedestrian-friendly city in accordance with the concept of walkable city. Speck (2012:11) describes it as a "simple, practical-minded solution to a host of complex problems that we face as a society, problems that daily undermine our nation's economic competitiveness, public welfare, and environmental sustainability". Southworth (2005:248) emphasises that space is friendly to pedestrians when "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". For a space to be friendly, first of all it must be accessible. According to Speck (2012:10), in order to achieve accessibility, "a walk has to meet four main conditions. It must be useful, safe, comfortable, and interesting. Each of these qualities is essential and none alone is sufficient". The result of Speck's extensive analysis is 'Ten Steps of Walkability' based on the aforementioned four conditions necessary for walking. These steps are as follows:

1. Put Cars in Their Place – to change the hierarchy in space design, where the pedestrian is the main factor determining the shape of the city.
2. Mix the Uses – by finding the right balance between the functions of objects and space. A walk must have a purpose, so the offer of services in the district should be diversified.
3. Get the Parking Right – take into account ecological considerations and pollution reduction, but also attempt to change residents' thinking and increase the importance of public transport.
4. Let Transit Work – because it is the core of the most pedestrian-friendly cities.
5. Protect the Pedestrian – primarily referring to safety, involving many factors such as: direction of traffic flow, traffic lights, size of buildings, speed limits.
6. Welcome Bikes – emphasise the presence of bicycle transport in the city as well as the need for appropriate bicycle infrastructure.
7. Shape the Spaces – underline the importance and sense of balance between open spaces and their edges (the need for comfort and pedestrian safety).
8. Plant Trees – because both trees and public transport are needed in the city space.
9. Make Friendly and Unique Faces – refers to the code for design of cities to make them interesting for passers-by, where active faces are the key to success.
10. Pick Your Winners – among the city's new road investments. They must be carefully planned to avoid wasting resources.

The principal arguments for making our cities more walkable are not incidental, and include wealth, health, and sustainability. Both wealth and health are closely interconnected, and determine the quality of life (Speck, 2012). The assumptions of the idea are supported by the World Health Organisation, promoting the health of the population and fight against obesity (Pucher and Dijkstra, 2003; Southworth, 2006; UN-Habitat, 2016).

The walkability of urban public space for all its users is connected with the issue of accessibility of the space for people with special needs. It is reflected in the universal design theory, defined as "simply a way of designing a building or facility at little or no extra cost so it is both attractive and functional for all people disabled or not" (Mace, 1985:147). According to Vanderheiden and Tobias (1998:584), "universal design is the process of creating products (...) usable by people with the widest possible range of abilities, operating within the widest possible range of situations (environments, conditions, and circumstances)". The Universal Design (UD) concept coined by Mace was expanded by the Centre for Universal Design (CUD) at North Carolina State University (US) (1997) through establishing seven principles for the universal design of products and environments. These principles are:

1. Equitable Use means equally available and useful structures and products for people of different abilities.

2. Flexibility in Use provides users of different abilities with options for accessing a built environment structure or product.

3. Simple and Intuitive Use concerns easy to understand designs that accommodate people of all abilities.

4. Perceptible Information concerns enabling users of all sensory abilities to readily access information and use a structure or design for its intended purpose

5. Tolerance for Error concerns built-in features that minimise hazards caused by accidents or unintended actions

6. Low Physical Effort refers to a structure or product that minimises user fatigue.

7. Size and Space for Approach and User enables users of all abilities to approach and use a built environment structure or product (Gray et al., 2012:95).

Literature on the subject also cites the eighth principle of universal design, authored by Kaletsch (2009), namely Perception of Equality. It draws attention to the emotional perception of space by each user. It is worth emphasising that the application of universal design principles does not only cover architectural and construction solutions. It applies to spatial planning, design of information, and communication technology (Wysocki, 2017). It therefore contributes to the improvement of the quality of life, particularly for people with disabilities (1).

The importance of the topic in the current design of cities is emphasised by the number of countries (181) that have ratified the Convention on the Rights of Persons with Disabilities (CRPD) (2006). Poland joined this trend relatively late, and has paid too little attention to the principles of universal design or pedestrian situations so far. This changed dramatically with the coming into force of the Act of 19 July 2019 on ensuring accessibility for persons with special needs (Journal of Laws 2019, item 1696). Its provisions obliged local governments in Poland to apply solutions in the investment process favouring accessibility of public space for all its users on an equal basis. The Act also introduces a new issue of accessibility certification (it will come into force from March 2021). Its purpose is to confirm whether an entity provides accessibility for persons with special needs. Such activities are to be financially supported under governmental programme 'Accessibility Plus' (2).

The issues of walkable city and universal design have been so far discussed separately (Mace, 1985; Southworth, 2006; Kaletsch, 2009; Speck, 2012; Toruń et al., 2017; Reisi et al., 2019) more often than together (Gray et al., 2012; *How walkable* …, 2015; Nykiforuk et al., 2017). Nonetheless, current research in the scope has shown a need for a greater focus on the incorporation of UD principles and other issues in current built environment instrumentation related to walkability. It also reveals a need for the development of measurement instruments that would provide more detailed information on environmental accessibility for people with a variety of disabilities to can help build communities that allow the population-at-large to lead healthy, active lives (Gray et al., 2012: 98). This is particularly important in Poland, where both the requirements of social life and passing of the Act call for the development of new methods and tools for the implementation of universal design and walkability rules aimed at reducing obstacles and barriers to mobility, and improvement of the accessibility of urban spaces for people with special needs.

The objective of the paper is to examine the impact of design concepts of walkable city and universal design on the practical aspects of life of people with disabilities in selected cities, with particular consideration of obstacles existing in public spaces. The main contribution of this study is twofold. In the methodological aspect, a synthetic index was developed based on the 'Ten Steps of Walkability'. In practical terms, it was analysed from both the spatial aspect using the UD principles (field inventory) and social perspective (semi-structured interviews, questionnaire survey). Based on the above, two specific objectives were adopted:

1) delimitation of the walkable and unwalkable districts/units in the city,

2) identification of barriers and obstacles in the city space relevant to universal design principles.

These analyses resulted in the preparation of a mental map presenting obstacles and barriers to movement of people with special needs.

The analysis covered the cities of Lublin and Gdynia, where the ideas of walkability and universal design are introduced based on various strategies. In Lublin, their introduction is the result of bottom-up activities initiated in 2014 in connection with the establishment of the Year of Jan Gehl, and the implementation of the 'Cities for People' project resulting in the publication of the 'Atlas of Pedestrian Situations' (2016) and issue of the Ordinance of the Mayor of Lublin City on 9 February 2017 (No. 20/2/2017). The annual 'Liveable Street' initiative is an extension of bottom-up activities. In Gdynia, a top-down strategy is used. The policy of the city authorities primarily focuses on the principles of universal design and adopted 'Accessibility Standards' (2013). The city takes account of the Standards in all public investments, and acts in the context of their inclusion in private investments.

2. Material and research methods

2.1. Study area

The study area covered two urban centres in different parts of Poland, comparable in terms of population and surface area. The first one is Gdynia (Pomeranian Voivodeship, N Poland, 54°31′09″N 18°32′22″E), one of the three cities forming the polycentric metropolitan area of the Tri-City on the Gulf of Gdansk. The population of Gdynia in 2018 was 246 309 (https://bdl.stat.gov.pl). The city has an area of 135 km^2, and is divided into 22 districts (auxiliary units) (Fig. 1). Gdynia is characterised by a unique land use structure dominated by forests (46%) (www.bip.um.gdynia.pl), varied land relief (relative heights above 200 m), and meagre river network consisting of small rivers and streams.

The second city is Lublin (capital of the Lubelskie Voivodeship, E Poland, 51°15′N 22°34′E), located on the eastern border of the EU and less than 100 km from Ukraine. The city has an area of 147 km^2, and is divided into 27 districts (auxiliary units) (Fig. 2), with a population of 339,682 inhabitants in 2018 (https://bdl.stat.gov.pl/). Lublin is the core of a metropolitan area with a population of more

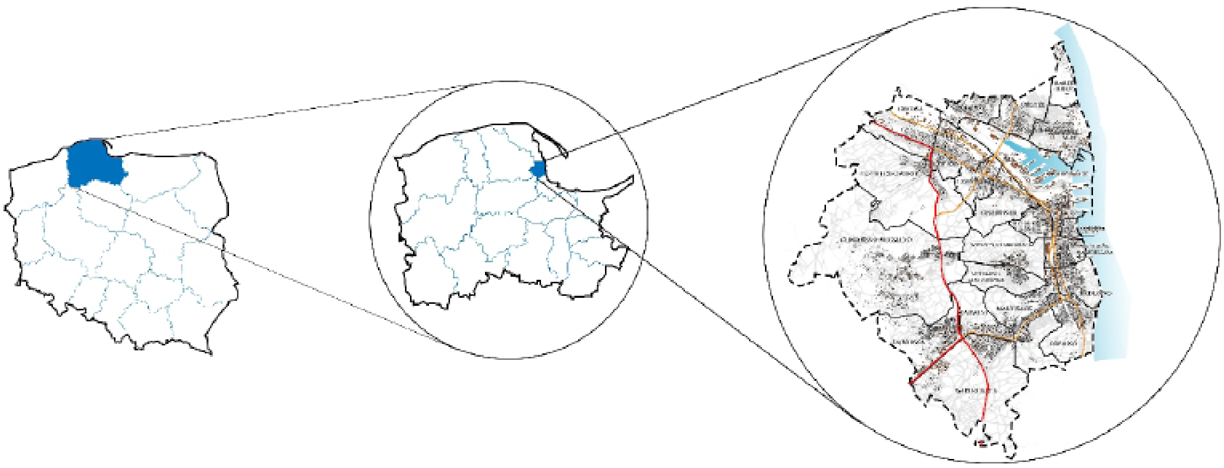

Fig. 1. Location of Gdynia with division into districts (auxiliary units)
Source: authors' elaboration based on www.gis-support.pl/dane-do-pobrania/

than 400 thousand. The area of the analysed city is heterogeneous in terms of terrain – the western part is located within the range of a loess plateau with diversified land relief (relative heights reach 70 m, with characteristic extensive dry valleys). The eastern part of the city features homogenous topography. The axis of the city is a wide valley of the Bystrzyca River. The south of the city features a 280 ha artificial water reservoir called Lake Zemborzycki surrounded by forest complexes.

2.2. Methods

Indicator selection based on 'Ten Steps of Walkability'

The research programme included both quantitative and qualitative analyses. The quantitative research was based on indicators developed in order to comprehensively verify auxiliary units in the selected cities in accordance with the concept of walkable city. The selection of individual indicators that make up the final result of the synthetic index was not incidental. They comprised an original selection of features based on the theoretical concept of 'Ten Steps of Walkability' (Speck, 2012).

Based on the concept's assumptions, 11 features were selected that are directly related to pedestrian, bicycle, and public transport, and verify the availability of services as well as open and green public spaces, and possible inconveniences associated with crossing of multi-lane arterial roads by pedestrians. The selected features provided results in numerical form permitting their comparison for all units. The division of the cities into auxiliary units, valid at the end of 2018, was used for the purpose of the analysis (Gdynia – 22 units, Lublin – 27 units). The features considered in the synthetic index are presented in Table 1.

The calculation of the presented indicators employed indirect data, mostly calculated by the authors based on the available geoprocessing sources and tools, analysis, and geometry in QGIS. Available and free of charge GIS and OSM data were developed using geoprocessing, geometry, analysis, and data management tools. The data were supplemented and verified by means of map services of the analysed cities, valid Studies of Conditions and Directions of Spatial Development of Cities, and google satellite hybrid underlay. The data providing the basis for calculating the 11 indicators included: surface area of districts in square kilometres and population (as of 31.12.2018), number of city bike stations in districts of the analysed cities, calculated from location maps of city bike stations, and length of bicycle paths (km) in districts based on a map presenting bicycle paths. Other indirect data used in the study included: number of bus connections in a district calculated based on the number of urban transport connections passing through the district (at least one bus stop served by a given bus line in the unit), and road length features with a classification into categories calculated based on publicly available data from the Head Office of Geodesy and Cartography (GUGiK). The calculation of the

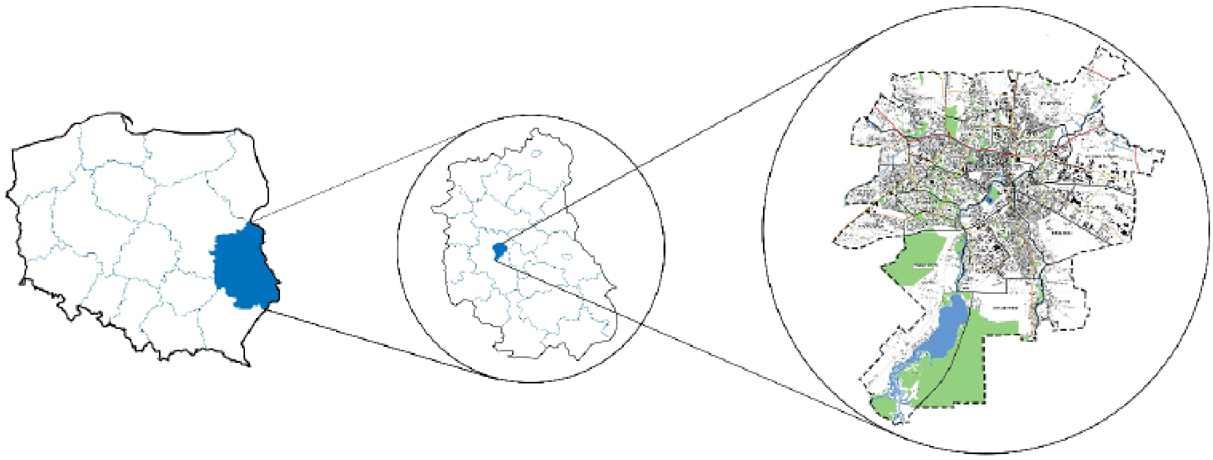

Fig. 2. Location of Lublin with division into districts (auxiliary units)
Source: authors' elaboration based on www.gis-support.pl/dane-do-pobrania

Table 1. Features considered in the synthetic index related to 'Ten Steps of Walkability' (Speck, 2012)

	Features	Walkability steps
1	Percentage of city bike stations in the district	Welcome Bikes
2	Length of bicycle paths (km) per km²	Welcome Bikes
3	Percentage of bus connections in the district	Let Transit Work, Get the Parking Right
4	Share of green areas (without allotment gardens and cemeteries)	Plant Trees, Shape the Spaces
5	Buildings density (m³/m²)	Shape the Spaces
6	Percentage of undeveloped land in the district	Pick Your Winners
7	Density of main roads of accelerated traffic and main roads per km²	Put Cars in Their Place, Protect the Pedestrian
8	Density of other road categories per km²	Put Cars in Their Place, Protect the Pedestrian
9	Educational services per km²	Mix the Uses
10	Religious facilities per km²	Mix the Uses
11	Services per km²	Mix the Uses, Make Friendly and Unique Faces

(Source: authors' elaboration)

surface area of green spaces in the districts, and the surface area of undeveloped areas (green areas, forests, and closed areas were not taken into account) involved drawing polygons and their conversion by means of field statistics in QGIS (3). The cubic capacity of buildings in units was obtained based on the calculation of the surface area of each building in the city, followed by manual assigning of the number of storeys, and finally multiplication and summing up of the results.

After obtaining the aforementioned data set, the data were converted into 11 indicators, verified for statistical significance by the coefficient of variation and Pearson's linear correlation coefficient.

Indicator normalisation

The synthetic index method requires data transformation. The normalisation process involved rescaling the original data to a uniform range for all variables, e.g. [0-1] or [0,100] (Jakubowski 2019: 23). For transformation purposes, all indicators were previously classified as stimulants (features that we evaluate positively) or destimulants (4) (features that we evaluate negatively). In this study, data normalisation employed formulas 1 and 2. As a result, all normalised features reach values between 0 and 100, regardless of whether they were classified as stimulants or destimulants. The following formula was applied to stimulant features (Eq. 1):

$$H_{ij} = \frac{(H_{ij} - x_{i\,min})}{x_{i\,max} - x_{i\,min}} \times 100$$

and the following one to destimulant features (Eq. 2):

$$H_{ij} = \frac{(x_{i\,max} - H_{ij})}{x_{i\,max} - x_{i\,min}} \times 100$$

where:

X_{ij} – empirical value of the i-th meter in the j-th territorial unit

$X_{i\,min}$ – the lowest value of the i-th meter among the examined subregions,

$X_{i\,max}$ – the highest value of the i-th meter among the examined subregions (Jakubowski, 2019:23).

Synthetic index

The last stage involved obtaining a synthetic index from the previously standardised features based on the following formula (Eq. 3):

$$W_s = \frac{\sum_{j=1}^{p} y_{ij}}{p}$$

where:

W_s – synthetic index

y_{ij} – standardised value of the j-th feature for the i-th unit

p – number of features taken into account (Jakubowski, 2019:23).

Finally, after summing up all the standardised characteristics and dividing them by the number of those characteristics, one synthetic index was obtained, allowing for the classification of auxiliary units from 1 to 22 in the case of Gdynia, and from

1 to 27 in the case of Lublin. The district ranked number 1 in the classification is the most walkable unit in the selected city.

Route selection

The method presented above permitted selection of two districts in each urban centre (in accordance with the classification: first and last auxiliary unit) for further in-depth analysis. The verification of the units in terms of accessibility of public space for people with disabilities involved an analysis of the built environment of the district with regard to the 7 UD principles and examples of their use (see: Mace, 1985; Gray et al., 2012:95, table 2). The routes were chosen because they contained key facilities and services that people would tend to walk to *(How walkable …,* 2015), such as a post office, bank, pharmacy, shops, city offices, recognisable public spaces (e.g. squares , marketplaces), bus stops, leisure facilities, or parks. It provided the basis for the designation of routes in the districts with particular consideration of the applied planning and design solutions and their practical use by all space users. A field inventory was carried out in both selected districts of Gdynia and Lublin, documented in the form of photographs, and barriers were visualised in the graphic form by means of maps.

One route was selected within each district based on several criteria. The routes corresponded to the paths of the individual, not only residents, but also people from other districts and the entire city, and included a public transport stop as a starting point in accordance with the concepts of walkable city and universal design. The boundaries of the analysed unit were also assumed to include an important public object (if it exists) and elements encountered by pedestrians on a daily basis that may constitute obstacles or barriers to movement.

During the inventory in the selected areas, the greatest attention was paid to the elements of development constituting potential barriers or obstacles to movement primarily for people with disabilities. The following emerging (or not) elements were of the most importance: small architecture such as rubbish bins and benches, green areas including trees, road infrastructure such as pavements, lighting fixtures, bus stops, as well as road signs, curbs, railings, flashing lights and audible crosswalk signals, wide doorways, options for use of ramps, stairs, grab bars, escalators, lifts etc.

Moreover, the following were analysed: the quality of the examined infrastructure, its availability, functionality, as well as whether it actually provides space for pedestrians and not parking for cars. Following the designated routes, the widths of pedestrian routes, the possibility to evade pedestrians, and the location of all the aforementioned elements in relation to the width of the pavement were also important.

Interviews and questionnaire survey

The research included two semi-structured interviews (Laforest, 2009; Azmi, Karim, 2012) with experts with disabilities and their environment in order to gain practical knowledge regarding obstacles and barriers encountered when moving around the city, and the needs of people with a particular dysfunction related to movement, vision, hearing, etc. The collected data were supplemented by a questionnaire addressed to the residents of selected city districts. The survey aimed at learning the opinions of residents (regardless of their level of ability and mobility) regarding their place of residence, mainly in terms of accessibility, walkability, and obstacles existing in the space. The questionnaire included 18 questions concerning the following: pedestrian accessibility, infrastructure adaptation, presence of barriers and obstacles in the space and their types, correctness of space management and safety, accessibility of green areas, and mobility of residents in the district. Due to the global pandemic situation, the survey was conducted in the electronic form. Because of the relatively small research sample (n=58), the results are supplementary and illustrative.

3. Results

3.1 Synthetic index

Based on the calculations of the synthetic index for the city of Gdynia (Table 1), the most pedestrian-friendly district proved to be Kamienna Góra, the smallest district of the city. It is located on a hill, borders on the Śródmieście district, and has direct access to the sea. It is characterised by the highest population density and primarily post-working-age population. The lowest value of the index was obtained for Pustki Cisowskie – the second largest district of the city, characterised by low population density typical of bedroom community.

The difference in the index value for both districts exceeded 40 (Table 1). Kamienna Góra obtained the highest scores for the following features: length of bicycle paths, density of buildings, density of main roads of accelerated traffic and main roads (5), and education services. The district also reached high values of other indicators related to services and density of other road categories. According to the results of the synthetic index, Pustki Cisowskie, the least pedestrian-friendly unit in the analysed city, obtained the lowest values for as many as 6 out of 11 features. The only exception is the indicator "share of green areas", due to the existence of extensive forest areas around the housing development.

Based on the calculations of the synthetic index for the city of Lublin (Table 2), the most pedestrian-friendly district proved to be Śródmieście (City Centre). It is one of the most representative units of Lublin, characterised by a very diversified functional structure with a dominant type of multi-family housing development, and an important transfer point (bus station) and retail infrastructure (marketplace). The lowest value of the synthetic index was obtained by the Hajdów-Zadębie district, located in the eastern outskirts of the city. It is sparsely populated, and dominated by the industrial function (it features among others a sewage treatment plant), with a large share of agricultural land.

The difference in the value of the indicator for both districts was 54. Śródmieście obtained the highest values for the following features: percentage of city bike stations, percentage of bus connections, buildings density, education services, and religious facilities. The district also obtained high values for other indicators related to services and density of other road categories. Hajdów-Zadębie obtained the lowest value only for 1 of the 11 features – the share of green areas (without allotment gardens and cemeteries).

The synthetic index for auxiliary units in selected cities (Gdynia – Fig. 3 and Lublin – Fig. 4) also showed that central districts are much more pedestrian-friendly than the outskirts. This is directly related to the development of the units, where old multi-family buildings prevail, especially post-socialist housing estates with infrastructure tailored to the needs of different population groups and designed with a much higher proportion of greenery.

3.2 Routes

The auxiliary units of the cities identified by the index were examined in more detail in terms of accessibility for pedestrians. In the boundaries of Kamienna Góra, the determined route was approximately 1 km long (average walking time was 14 minutes), and included elements such as a public transport stop at the future Central Park (starting point), an intermediate view point to the sea, and the funicular to Kamienna Góra (end point), leading down to the Musical Theatre. The route ran in the surroundings of both detached houses (in the northern part) and multi-family houses (in the southern part). It is shown in Fig. 5.

In the boundaries of Pustki Cisowskie, the designated route was approximately 0.8 km long (average walking time was 10 minutes), and included elements such as a public transport stop allowing for access to the 'Marszewo' Forest Botanical Garden (starting point), an intermediate point – a post office located in a multi-family building on the ground floor, and a multi-family building located west of expressway S6 (end point) dividing the district into two parts. The first half of the route ran among detached houses, and the second half through a housing estate of multi-family blocks of flats. It is shown in Fig. 6.

The route in Śródmieście in Lublin was approximately 1 km long (average walking time was 12 minutes), and included elements such as a public transport stop near the historical church and theatre (starting point), an intermediate point – square Plac Litewski constituting one of the most recognisable public spaces of the city, and the City Hall (end point). The route was surrounded by high quarter buildings. It is presented in Fig. 7.

Table 2. Standardised 11 features for Gdynia, divided into auxiliary units with synthetic index and classification

No.	District	Percentage of city bike stations in the district	Length of bicycle paths (km) per km²	Percentage of bus connections in the district	Share of green areas (without allotment gardens and cemeteries)	Buildings density (m³/ m²)	Percentage of undeveloped land in the district	Density of main roads of accelerated traffic and main roads per km²	Density of other road categories per km²	Educational services per km²	Religious facilities per km²	Services per km²	Synthetic index	Classification
1	Babie Doły	0,0	26,6	0,0	72,4	2,1	87,7	71,7	8,5	6,4	19,5	1,2	**26,92**	**16**
2	Chwarzno- Wiczlino	25,0	1,9	8,7	87,0	3,7	45,3	79,5	12,1	2,8	0,6	0,0	**24,24**	**19**
3	Chylonia	43,8	10,6	41,3	19,7	59,4	11,8	58,9	44,8	28,9	49,2	25,5	**35,80**	**6**
4	Cisowa	25,0	15,4	17,4	55,9	23,5	43,4	53,2	18,7	4,6	22,9	14,8	**26,80**	**17**
5	Dąbrowa	31,3	11,5	30,4	62,0	25,3	27,0	55,2	39,5	4,2	4,8	6,8	**27,10**	**15**
6	Działki Leśne	37,5	5,3	63,0	53,2	59,0	2,7	53,9	69,5	41,0	100,0	70,9	**50,55**	**2**
7	Grabówek	18,8	16,8	39,1	71,5	19,6	1,2	75,0	12,6	13,9	8,2	29,9	**27,87**	**14**
8	Kamienna Góra	12,5	100,0	4,3	4,4	100,0	0,0	100,0	81,7	100,0	74,2	79,0	**59,64**	**1**
9	Karwiny	37,5	14,4	32,6	85,6	21,7	1,8	65,4	19,1	23,1	41,3	17,1	**32,70**	**10**
10	Leszczynki	25,0	15,6	50,0	45,1	31,3	7,6	9,7	62,0	10,9	33,3	24,6	**28,64**	**12**
11	Mały Kack	43,8	14,3	23,9	64,0	18,4	23,1	74,2	32,8	3,1	9,4	5,3	**28,38**	**13**
12	Obłuże	37,5	12,0	50,0	0,0	30,0	100,0	56,3	31,8	39,4	24,3	52,7	**39,45**	**5**
13	Oksywie	31,3	26,4	30,4	31,4	35,2	40,1	69,1	31,3	14,0	42,8	25,2	**34,28**	**9**
14	Orłowo	31,3	29,5	39,1	56,0	32,2	5,3	61,0	48,5	18,5	46,8	18,7	**35,17**	**7**
15	Pogórze	25,0	21,9	30,4	21,4	40,0	31,3	55,0	56,4	5,9	39,4	27,9	**32,24**	**11**
16	Pustki Cisowskie	6,3	0,0	6,5	100,0	0,0	1,1	83,6	0,0	0,0	0,0	0,0	**17,95**	**22**
17	Redłowo	37,5	15,6	47,8	57,9	46,5	8,7	69,6	40,5	10,0	30,7	12,8	**34,34**	**8**
18	Śródmieście	100,0	23,9	100,0	14,9	42,2	9,7	65,4	22,0	7,5	18,6	92,4	**45,15**	**4**
19	Wielki Kack	25,0	0,7	26,1	85,7	6,4	14,1	73,1	16,4	1,1	3,4	1,4	**23,05**	**20**
20	Witomino- Leśniczówka	6,3	10,4	15,2	84,1	22,6	2,1	86,8	14,5	3,9	12,1	11,4	**24,51**	**18**
21	Witomino- Radiostacja	6,3	4,8	15,2	94,0	7,2	3,1	89,6	0,4	11,5	6,3	1,2	**21,77**	**21**
22	Wzgórze Św. Maksymiliana	18,8	49,6	54,3	29,4	83,5	12,5	0,0	100,0	66,3	22,5	100,0	48,81	3

Source: authors' calculation

Table 3. Standardised 11 features for Lublin, divided into auxiliary units with synthetic index and classification

No.	District	Percentage of city bike stations in the district	Length of bicycle paths (km) per km^2	Percentage of bus connections in the district	Share of green areas (without allotment gardens and cemeteries)	Buildings density (m^3/m^2)	Percentage of undeveloped land in the district	Density of main roads of accelerated traffic and main roads per km^2	Density of other road categories per km^2	Educational services per km^2	Religious facilities per km^2	Services per km^2	Synthetic index	Classification
1	Abramowice	7,14	3,39	7,32	100,00	0,18	36,37	91,62	0,00	0,52	0,00	0,03	22,4	**24**
2	Bronowice	7,14	35,06	36,59	16,46	46,79	10,13	67,04	62,80	38,94	8,34	19,72	31,7	**14**
3	Czechów Południowy	42,86	57,23	36,59	29,24	57,73	37,02	65,99	67,96	35,43	18,76	30,72	43,6	**5**
4	Czechów Północny	42,86	39,05	41,46	8,34	26,28	57,36	63,08	37,32	13,02	7,10	17,40	32,1	**13**
5	Czuby Południowe	21,43	43,26	43,90	42,51	49,55	53,80	75,30	44,58	35,99	10,80	23,35	40,4	**6**
6	Czuby Północne	35,71	53,02	46,34	42,02	56,32	28,21	45,77	69,75	51,60	18,21	30,52	43,4	**7**
7	Dziesiąta	35,71	15,33	36,59	11,86	32,90	8,55	75,53	66,74	15,84	9,51	15,36	29,4	**11**
8	Felin	28,57	24,51	41,46	2,06	21,22	51,04	54,79	29,63	6,99	3,00	18,63	25,6	**21**
9	Głusk	0,00	6,12	0,00	4,19	5,31	100,00	100,00	15,37	7,35	3,67	0,20	22,0	**25**
10	Hajdów-Zadębie	7,14	6,96	9,76	0,00	6,87	79,86	72,43	14,93	1,55	2,33	1,81	18,5	**27**
11	Kalinowszczyzna	28,57	41,41	36,59	35,50	50,30	46,21	49,32	63,47	43,16	22,85	13,69	39,2	**8**
12	Konstantynów	21,43	33,63	39,02	10,39	54,34	0,00	38,82	69,49	38,97	29,22	14,40	31,8	**10**
13	Kośminek	14,29	2,07	14,63	1,07	14,98	56,37	80,37	36,68	13,01	9,76	3,16	22,4	**23**
14	Ponikwoda	14,29	4,69	14,63	2,62	12,35	90,71	97,83	42,88	7,26	3,63	2,16	26,6	**18**
15	Rury	50,00	49,12	63,41	41,12	65,92	25,73	76,45	65,86	54,15	17,41	37,21	49,7	**2**
16	Sławin	21,43	14,42	19,51	12,82	17,82	65,17	72,72	45,02	5,90	17,69	10,70	27,6	**17**
17	Sławinek	7,14	6,84	12,20	12,44	44,58	23,31	58,65	93,87	23,27	23,27	33,07	30,8	**12**
18	Stare Miasto	7,14	59,39	43,90	22,03	39,27	73,01	45,31	46,79	29,71	22,28	100,00	44,4	**4**
19	Szerokie	7,14	8,61	4,88	2,39	14,97	61,37	56,90	77,09	0,00	19,82	5,24	23,5	**26**
20	Śródmieście	100,00	54,44	100,00	17,09	100,00	7,69	46,60	86,31	100,00	100,00	84,87	72,5	**1**
21	Tatary	28,57	18,13	34,15	8,14	58,76	17,74	56,09	39,81	25,35	6,91	11,86	27,8	**19**
22	Węglin Południowy	28,57	17,01	39,02	4,70	22,52	68,35	66,72	65,50	4,11	8,21	11,89	30,6	**15**
23	Węglin Północny	7,14	0,00	12,20	8,77	21,11	36,99	78,35	100,00	5,84	8,76	6,40	26,0	**20**
24	Wieniawa	42,86	64,70	53,66	35,28	71,45	18,41	13,76	71,96	82,51	19,04	22,72	45,1	**3**
25	Wrotków	21,43	60,21	34,15	6,84	40,32	31,64	100,00	47,24	15,55	9,33	10,61	34,3	**16**
26	Za Cukrownią	21,43	100,00	80,49	33,84	25,86	31,42	0,00	41,60	20,11	17,24	8,89	34,6	**9**
27	Zemborzyce	7,14	9,99	0,00	66,33	0,00	64,06	100,00	9,22	1,09	0,82	0,00	23,5	**22**

Source: authors' calculation

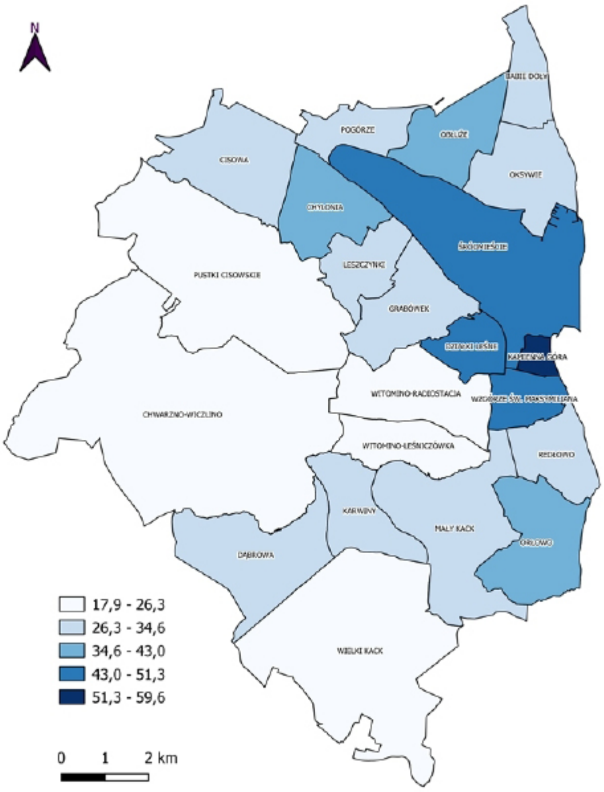

Fig. 3. The value of synthetic index for auxiliary units in Gdynia
(Source: authors' elaboration)

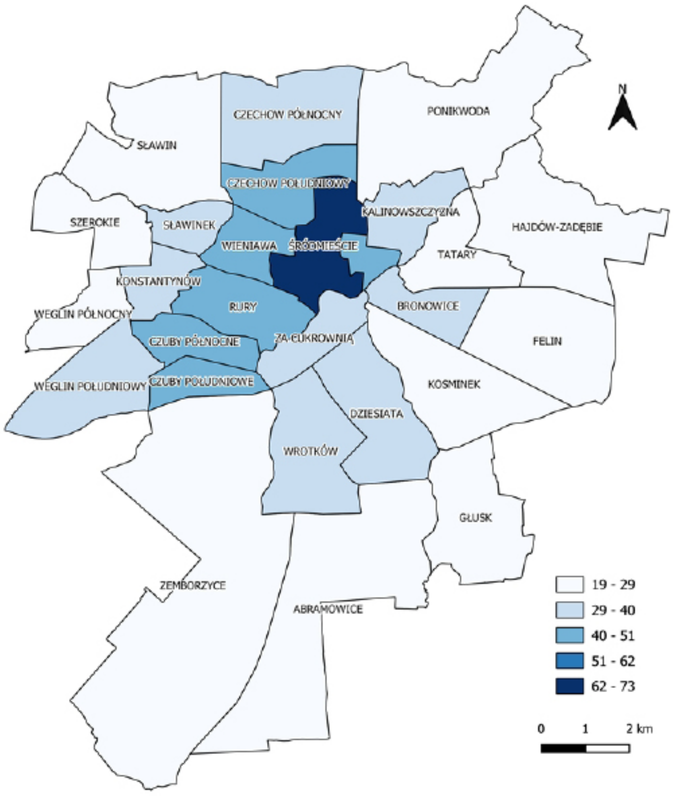

Fig. 4. The value of synthetic index for auxiliary units in Lublin
(Source: authors' elaboration)

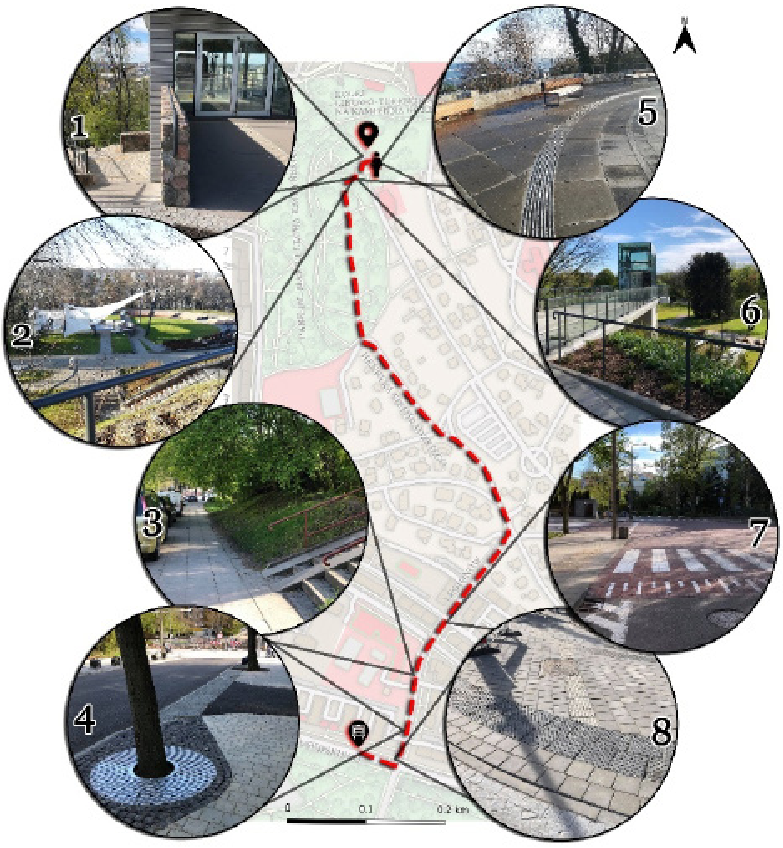

Fig. 5. Walking route in Kamienna Góra
(Source: authors' elaboration)

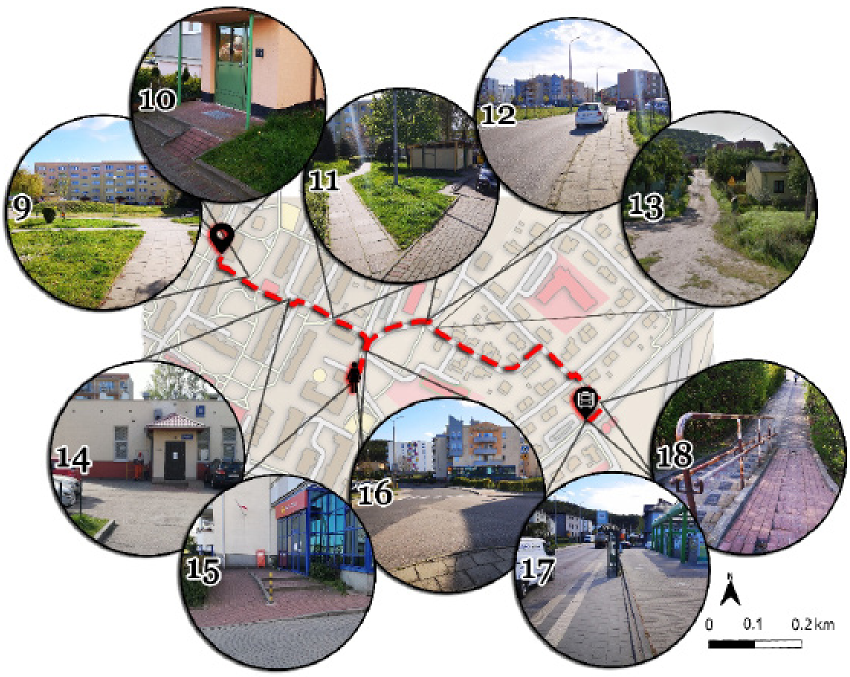

Fig. 6. Walking route in Pustki Cisowskie
(Source: authors' elaboration)

In the boundaries of Hajdów-Zadębie, the route was approximately 0.9 km long (average walking time was 11 minutes), and included elements such as a public transport stop (starting point), an intermediate point – the Poviat Labour Office, and the Outlet Center Lublin shopping centre (end point). The route ran along a wide roadway with three carriageways (Mełgiewska Street). It is shown in Fig. 8.

3.3 Obstacles in urban space

Inventory results

Various barriers and obstacles characteristic of each analysed district of the cities were identified, as well as common elements contributing to limited accessibility of public spaces for people with disabilities within the boundaries of the routes with regard to the 7 principles of universal design.

The most frequent obstacles for people with disabilities in the space for individuals included: too narrow walking paths (often because of cars parked on the pavement) (phot. 3,12,20), stairs (without ramps or lifts) and unpaved surfaces (phot. 2,13), lack of railings at stairs (phot. 10,15), significant differences in land height (phot. 2,6,18), bad condition of road infrastructure, or inadequate surfaces (phot. 13,21,34), as well as narrow doors (14). The illustrated obstacles are not reflected in almost all principles of universal design, especially 'Size and space for approach and use', 'Flexibility in use' and 'Low physical effort'.

Other, less obvious obstacles on the routes included elements such as: lack of clear separation of pedestrian and bicycle routes (phot. 29,30), protruding shop windows and gutters, unprotected surface around tree trunks, and movable advertisements in the width of the pavement (phot. 29), as well as small architecture and lanterns improperly located in the width of the pavement (phot. 24), glass elements without appropriate marking (phot. 6,19), multiple stage pedestrian crossings (phot. 31,32), and insufficient time to pass through the crosswalks, as well as complete lack of high greenery providing shade on hot days (phot. 30,31,32,33,34,35,36). In this set of obstacles, the largest share was constituted by elements relating to principles: Tolerance for error' and 'Simple and intuitive use'.

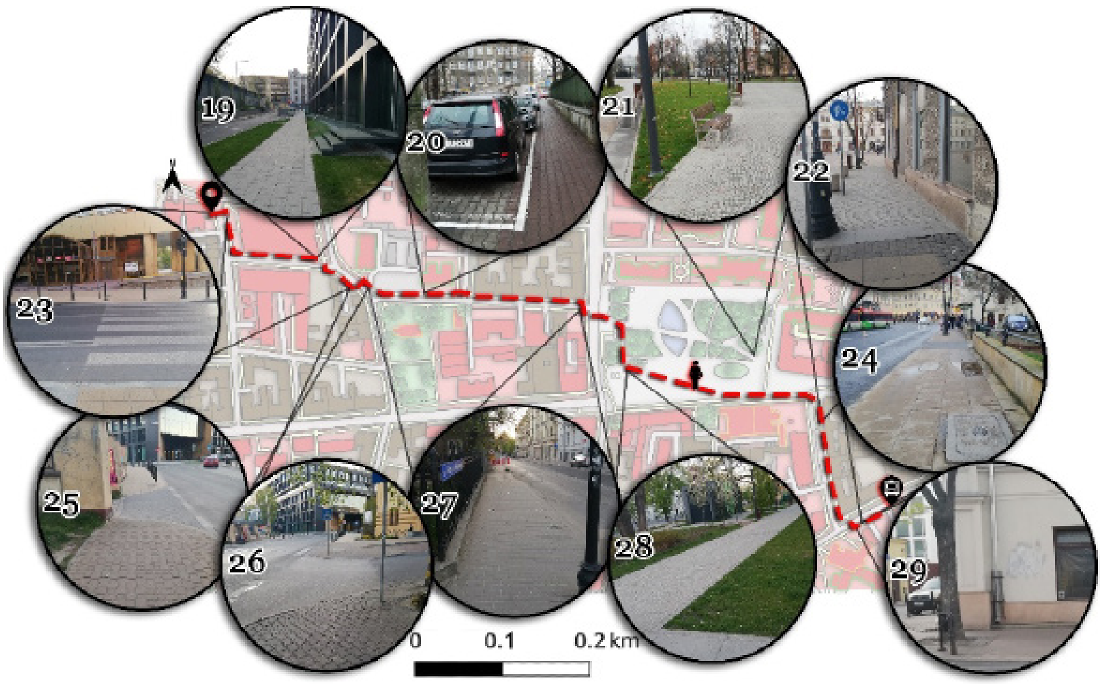

Fig. 7. Walking route in Śródmieście
(Source: authors' elaboration)

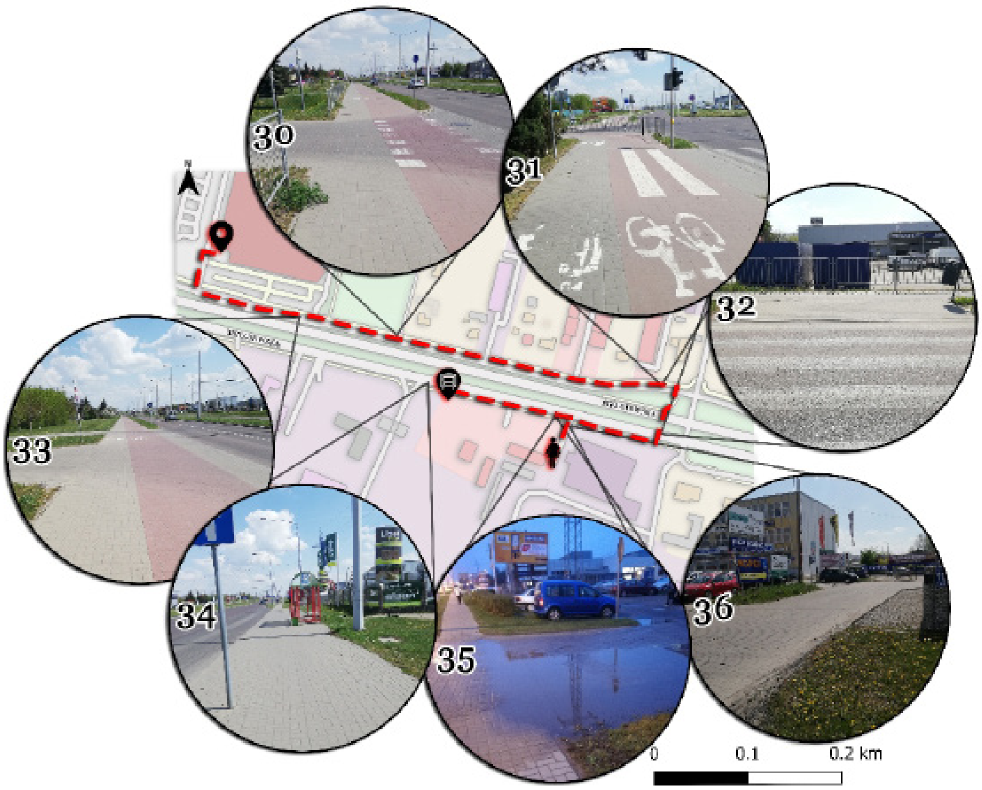

Fig. 8. Walking route in Hajdów-Zadębie
(Source: authors' elaboration)

Results of interviews and questionnaire survey

The semi-structured interviews with people with disabilities permitted gaining practical knowledge regarding barriers for persons with dysfunctions existing in the city.

During the interview, the Plenipotentiary of the Mayor for Persons with Disabilities drew attention to obstacles in the city space such as lack of separation of the bicycle path from the pedestrian route. Uneven surfaces, pillars potentially unnoticeable for a visually impaired person, and electric scooters subject to no appropriate regulations may pose a serious threat. The interviewee highlighted the barrier of still high level of social unawareness of the needs of people with disabilities.

An interlocutor from Lublin – a civil engineer, instructor at the Foundation for Active Rehabilitation (FAR), pointed out the obstacles in the city space such as: stairs, high kerbs, or glass railings and lack of their contrast marking. In the case of buildings, these are narrow doors, lack of railings at driveways and ramps, or unsuitable height of light switches, as well as a widespread lack of adaptation of cultural facilities for an organised group of wheelchair users, e.g. absence of a sufficient number of seats, often located only at the very bottom of the cinema hall or near the stage. The interviewee also emphasised that the basic assumption in design should be practical knowledge and comprehensive approach.

The questionnaire survey permitted obtaining the opinions of residents of the selected districts of Gdynia and Lublin (regardless of the level of ability and mobility) regarding the issue of accessibility and obstacles existing in their space.

Elements discouraging the respondents from walking around the district included (Fig. 9) scattered rubbish, as well as: hilly terrain, wild animals, and lack of driveways. The answers in category "other" added by the respondents were dominated by "bad condition of infrastructure" and "domination of cars".

Elements of space making walking around the city most difficult for respondents (Fig. 10) included: stairs, dead-end streets, lack of pavements, and high kerbs. Category "other" included answers such as "bad infrastructure", "low-quality roads and pavements", and "domination of cars".

Empirical results

The results of empirical research relating to obstacles in urban spaces identified based on 7 principles of universal design, as well as semi-structured interviews and questionnaire survey are compiled in Table 4.

Mental map

The knowledge gained in all three stages of the research was compiled in the form of an original mental map of barriers and obstacles in the city space (Fig. 11). The barriers were divided into four main groups. Three of them concern obstacles specific to the type of dysfunction. The last collection includes elements with potential negative impact on other users of the space, including the elderly, people with temporary mobility limitations, parents with small children, etc.

The largest set of barriers is related to movement dysfunctions. The quality of space is important from the practical point of view of the universal design concept. The majority of the aforementioned obstacles are closely related to the architectural aspect, such as stairs without ramps, or uneven pavement, making free movement very difficult for a wheelchair user, and requiring more physical effort from them. In the case of buildings, the obstacles include: lack of elevator, stairs on mid-floors, or toilets unsuitable for wheelchair users. According to the interviewee from Lublin, the lack or limited access of organised groups of wheelchair users to among others cultural and entertainment facilities is still a serious issue.

The second largest group of barriers concerns visual impairments. The desirable way to develop space involves high contrast colour markings for the visually impaired, and voice or sound signals for the blind. The availability of information in the form of voice or sound signals is of high importance for this group of recipients.

The most characteristic barriers in the case of hearing disfunctions include lack of adapted websites and applications, or the inability to call for help in times of danger. Another obstacle are narrow islands at pedestrian crossings.

The last group of possible obstacles concerns the broadest possible group of recipients, at different ages, of different occupations, etc. It includes obstacles potentially affecting every participant of society, regardless of age and stage of life, such as steep and long climbs, lack of elevators, lights changing too fast at pedestrian crossings, etc.

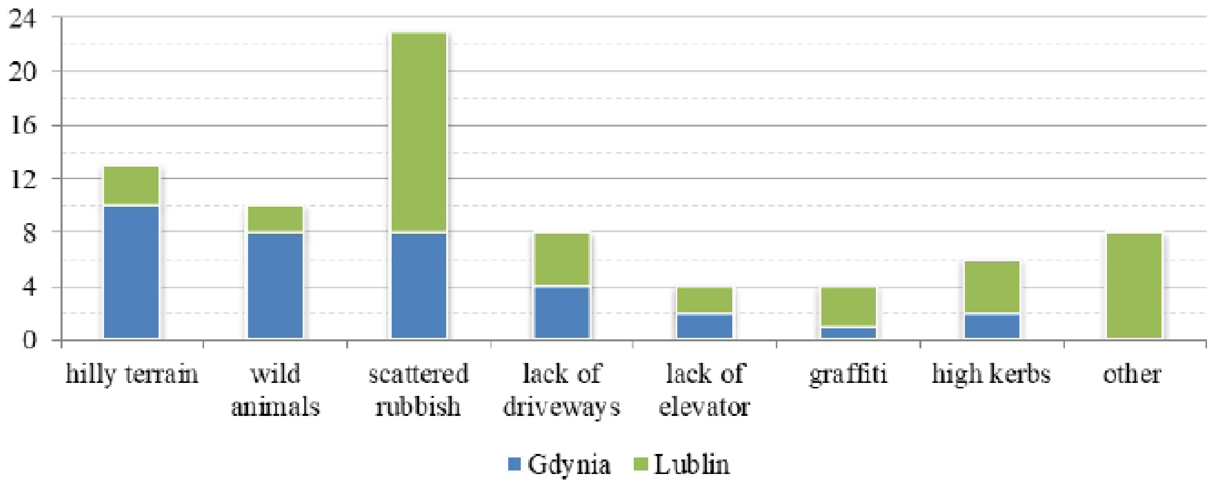

Fig. 9. Respondents' answers to the question regarding factors discouraging them from walking around the district (Source: authors' calculation)

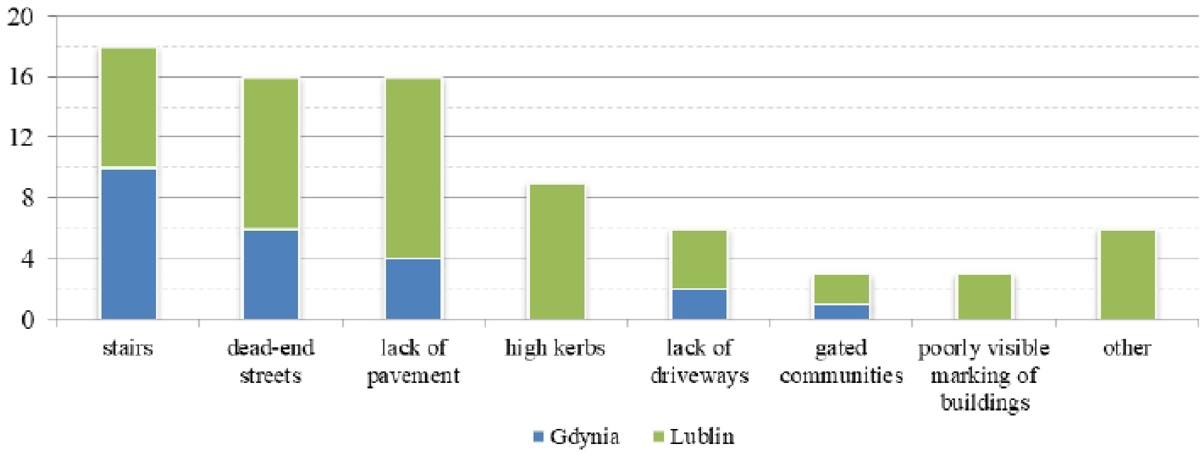

Fig. 10. Respondents' answers to the question regarding types of obstacles in the district
(Source: authors' calculation)

Table 4. Barriers and obstacles for people with disabilities based on the results of field inventory and social research

Group of people with special needs	7 UD principles	Social research
Wheelchair users	narrow footpaths, unsuitable level of lever handles and push buttons, lack of ramps and elevators, stairs, escalators, narrow doorways, hilly terrain, lack of railings at stairs, small architecture and lanterns improperly located in the width of the pavement	narrow footpaths, cars parked on sidewalks, high kerbing, stairs without ramps, uneven pavement, lack of elevators, stairs on mid-floors, unsuitable toilets, lack or limited access to among others cultural and entertainment facilities, no driveways, narrow doors, small architecture and lanterns improperly located in the width of the pavement, domination of cars
Persons with hearing loss	lack of meaningful icons, narrow islands at pedestrian crossings, lack of flashing lights	lack of adapted websites and applications, narrow islands at pedestrian crossings
Persons with visual difficulties	no contrast colour markings, lack of Braille on signage, lack of audible crosswalk signals, lack of tactile boundaries, small architecture and lanterns improperly located in the width of the pavement, high kerbing, cracked pavements, no separation of the cycle path from the pedestrian route	high kerbing, no high contrast colour markings, no voice or sound signals, no separation of the cycle path from the pedestrian route, small architecture and lanterns improperly located in the width of the pavement, glass railings, lack of websites with text-to-speech software
Persons with difficulties, such as elders, parents with young children, persons with reduced mobility	narrow footpaths, unsuitable level of lever handles and push buttons, high kerbing, lack of ramps and elevators, many stairs, hilly terrain, cracked pavements	high kerbing, long climbs, lack of ramps and elevators, lights changing too fast at pedestrian crossings, absence or poor condition of pavements, domination of cars

(Source: authors' elaboration)

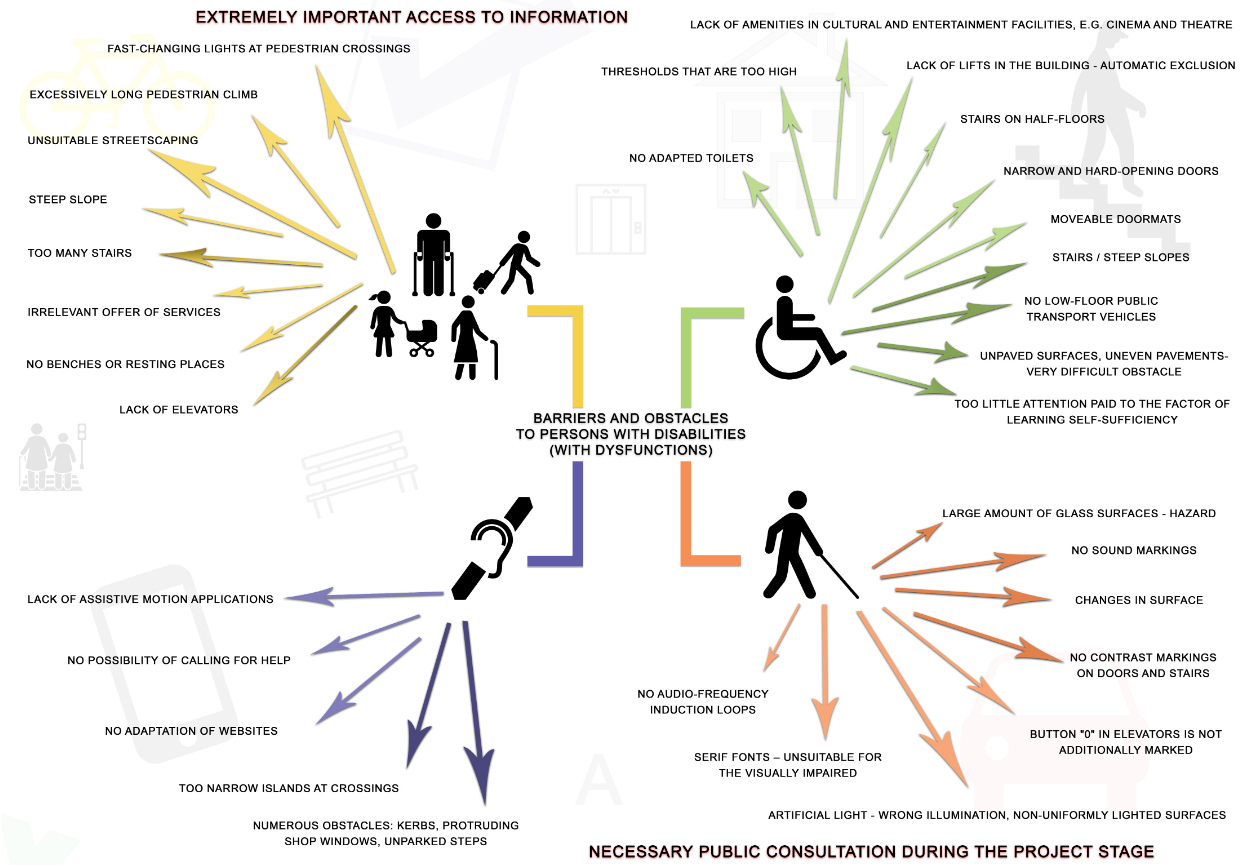

Fig. 11. Mental map of barriers and obstacles for persons with disabilities in the city space
Note: shades of arrows distinguish obstacles outside (darker) and inside (lighter) objects
(Source: authors' elaboration)

4. Discussion and Conclusions

Solutions for cities corresponding with the principles of the concept of walkable city (Southworth, 2005; Frank et al., 2006; Speck, 2012; Forsyth, 2015) and universal design (Mace, 1985; Vanderheiden, Tobias, 1998; Kaletsch, 2009; Gray et al., 2012; Gawron, 2015) are becoming more and more popular around the globe. This study involved the analysis of the situation in Poland. The implementation of the first objective permitted developing a synthetic index and its application to the auxiliary units in Gdynia and Lublin. A systematised classification of districts in terms of their walkability was developed, and the selection of indicators was based on the author's own evaluation of the criteria chosen for a given space, e.g. using The Walk Score (Toruń et al., 2017) or Walkability Index (Reisi et al., 2019). The results confirmed the importance of an environment built-up for the accessibility of pedestrian space. Auxiliary units located in the city centre, with a diversified service offer, compact development, and access to pedestrian and bicycle infrastructure scored much better than districts in the outskirts of the city, with a significant percentage of extensive development, predominance of detached houses or industrial and warehousing development, and a small percentage of services of various levels and types, classified as the least pedestrian-friendly. The elements influence of the built environment on walking is widely accepted (Frank et al., 2010; Christian et al., 2011; Sadik-Khan, Solomonow, 2017). It was also confirmed by the questionnaire survey according to which the quality of the surrounding living space and access to the service and recreation offer had a significant impact on the declared willingness of walking in the area of the analysed district. The results overlapped with other studies showing correlations between walking and proximity of services, accessibility and quality of infrastructure for pedestrians and cyclists, and safety (Hartig et al., 2014; Zuniga-Terann et al., 2017).

In accordance with the second specific objective related to the implementation of the concept of universal design, on the one hand field inventory of the selected routes was carried out, and on the other hand, social research regarding barriers and obstacles occurring in cities. The results (regardless of the location of the surveyed district) revealed a significant number of elements constituting barriers to mobility for people with and without disabilities. They include, among others, uneven pavements, domination of cars, and lack of elevators, railings, or staircase ramps, i.e. elements requiring special attention in the universal design process (Wysocki, 2017; Puławska-Obiedowska, 2017). The illustrated obstacles contradict the implementation of almost all principles of UD, especially in 'Flexibility in use', 'Low physical effort', Size and space for approach and use', 'Tolerance for error', and 'Simple and intuitive use'. It manifests the most common mistakes in planning and management of urban space, as well as failure to adjust it to the requirements of people with special needs. These results of field inventory were confirmed by the questionnaire survey and semi-structured interviews which additionally showed the necessity of public consultations at the stage of design of public spaces (although they are not stipulated by law). Effective building of an accessible and walkable space requires extending the survey to urban audits involving people with disabilities (*How walkable …*, 2015). The consideration of the needs of persons with disabilities should be incorporated into the future design or revision of generic built environment instruments to obtain information necessary for building an accessible community (Gray et al., 2012).

The research permitted development of a mental map presenting obstacles occurring both in the public space and public facilities of cities, correlated with practical solutions presented by *Plan and Design for Choice* (2009), Wysocki (2015), Kowalski (2016). It should be emphasised that the process of barrier elimination in the city space does not only involve the introduction of amenities and improvements for people with dysfunctions. The way of their implementation is extremely important. The principle of perception of equality by Kaletsch is crucial. The significance of the issue is confirmed by research and activities carried out in Lublin (Skrzypek, 2016), Poznań (Donderowicz-Wronkowska, Kaczmarek 2018), Łódź (Barański, 2017), or Białystok (Rawski, 2017). These are, however, individual activities and investments. Polish cities are generally not prepared to implement the concept of walkable city and universal design, as demonstrated by the presented research. That is why changes in the law and institutional and financial support for the implementation of universal design principles are of high importance. This also seems to be a good way to make our cities more walkable.

Finally, it should be emphasised that this study, although based on Polish reality, also has a broader context, and its results reveal challenges faced by local governments to make built environment more accessible. Cities will not be fully walkable unless the principles of universal design are introduced into their planning (*How walkable …*, 2015). Our study contributes to this idea through the development of an original methodology to examine spatial units in the scope of walkability, based on empirical material. The developed mental map can be used for universal design worldwide, because the needs of people with disabilities in the context of the use of public space and the existing obstacles are similar. Considering the results and their direct impact on the practical life of residents, it is recommended to extend the research to other cities.

Notes

1. By persons with disabilities we mean those with long-term physical, mental, intellectual, or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on equal terms with others (CRPD:6).
2. The 'Accessibility Plus' government programme was introduced in 2018 in order to permanently incorporate accessibility into all public policies, the practice of planning, implementing, and evaluating the functioning of the state, and to adapt architecture, transport, and products to the requirements of all citizens (https://www.gov.pl/web/fundusze-regiony/program-dostepnosc-plus).

3. The QGIS program calculated the surface area of each polygon. The obtained data were summed up in accordance with the boundaries of the auxiliary units of a given city.
4. The only feature that qualified as a destimulant was the density of main roads of accelerated traffic and main roads per km².
5. This means that the district has the smallest percentage of such roads per km² of the district – stimulant.

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