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Identification of Urban Sports Zones as a Potential Product of Sports Tourism Using Spatial Dispersion Indicators

Abstract. The purpose of this article is to identify urban sports zones (also known as sports cities) as a potential product of urban or sports tourism in Poland using the spatial dispersion indicator of residential buildings in relation to sports infrastructure buildings. In the study orthodromic distances (the shortest distances in Euclidean space) between over 7 million residential buildings and 5.4 thousands sports facilities were calculated using centroids of buildings data included in the Topographic Object Data Bank (BDOT10k). These orthodromic distances were then used to calculate the dispersion coefficient in order to identify concentration zones of sports infrastructure buildings. The outcome of the study was the distribution of sports infrastructure buildings in Poland along with concentration zones where communes were treated as functional units. The findings can be used to identify areas that could serve as sports cities, which are defined as varied, separate, large areas, whose development is associated with sport and recreation.

Keywords: sports tourism, spatial dispersion, BDOT10k, sports city, sports zones, urban tourism

1. Introduction

The challenge faced in city development is to create an attractive space for residents and visitors who often come as tourists. The continuous improvement of services available in cities leads to the creation of functionally specialised spaces. A city with competitive functional spaces may become a destination for residents

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pursuing recreational activities or in proximity tourism [see Soria, Llurdés Coit 2013]. Another growing phenomenon is urban tourism[1] in its various forms.

The practice of recreational or high-performance sports is also an example of activity which could benefit from the existence of specialized city space. Diverse participation in sport is a growing phenomenon in postmodern societies [Malchorowicz-Mośko 2015: 55-66]. According to Rzegocińska-Tyżuk [2012: 146-147], sports facilities are the factor of great importance in space creation by uniting people around common values represented by sport. To meet this requirement, urban space is being enriched with sports facilities. The challenge for urban organisms is to develop the attractiveness of such zones and to make them available for both city residents and outsiders.

Sports tourism is an ambiguous concept. UN WTO defines sports tourism as "type of tourism activity which refers to the travel experience of the tourist who either observes as a spectator or actively participates in a sporting event generally involving commercial and non-commercial activities of a competitive nature" [World Tourism Organization 2019: 54]. According to Gibson, who provided a review of the sports tourism literature [Gibson 1998], sports tourism includes three domains: active sports tourism (people travelling to take part in sports activities), sports event tourism (people travelling to watch sports events) and nostalgia sports tourism (visiting sports museums, famous sports venues). According to Weed and Bull [2009 as cited in Hadzik 2014], sports tourism is defined as all forms of active or passive participation in sport, both professional and amateur, for recreational or commercial purposes that require travel outside the place of residence and work. Standeven and DeKnop [1999: 12] define sports tourism as "all forms of active and passive involvement in sporting activity, participated in casually or in an organized way to non-commercial or business/commercial reasons that necessitate travel away from home and work locality". The concept of sports tourism is also thoroughly reviewed by Hinch and Higham [2004], who define it as "sport-based travel away from the home environment for a limited time, where sport is characterized by unique rule sets, competition related to physical prowess and a playful nature."

Kurtzman [2005] indicates the following positive effects that sports tourism may induce in the city:

– media coverage,
– employment (short-term),

[1] According to UNWTO, urban tourism is "a type of tourism activity which takes place in an urban space with its inherent attributes characterized by non-agricultural based economy such as administration, manufacturing, trade and services and by being nodal points of transport. Urban/city destinations offer a broad and heterogeneous range of cultural, architectural, technological, social and natural experiences and products for leisure and business" [World Tourism Organization 2019: 48; https://www.unwto.org/urban-tourism].

– shapes the city's image,
– tax benefits,
– development of infrastructure,
– economic impact,
– direct expenses,
– development of hotel accommodation,
– development of entertainment places.
– overall growth in the tourism sector,
– internationalization of the city and its business relations.

Development of specialized sports zones requires an appropriate spatial management policy and investments in sports infrastructure. Therefore, the creation or expansion of urban sports is a capital-intensive process burdened with financial risk. On the other hand, Smith points to the risk of creating a "sport-anchored tourist bubble", isolated from the rest of the city, which meets the needs of visitors but not those of ordinary residents of the city [Smith 2010: 394].

In view of those limitations, the location of urban sports zones should be carefully chosen. The problem concerns effectiveness of investments from the public and private sector. The public sector is responsible for urban spatial management and effective public investments in the sports infrastructure. An assessment of the potential of specific locations is also desirable in the case of market entities intending to develop their business in the segment of recreational and sports services.

As each investment activity in this area should be preceded by an analysis of a given location's attractiveness, the main research problem is to identify places which could be considered attractive urban sports zones. This problem requires a theoretical basis since a clear definition of such a zone and criteria of its delineation are required. To cope with this, the authors of this article define the notion of a sports city as a separated, large area of space where buildings are associated with sport and recreation, and due to their complexity, are called sports-city [Berbeka 2013: 13].

From the practical point of view, this problem is of interest to entities that make decisions about public or the private investments and look for ways of evaluating their effectiveness depending on the location chosen.

The main purpose of this article is to define urban zones of sports cities and identify locations of such zones as a potential product of sports tourism in Poland using the spatial dispersion indicator of residential buildings in relation to sports infrastructure buildings. For the purpose of identifying potential sports city zones the authors propose using an objective measure of concentration and dispersion of sports infrastructure buildings obtained from the centroid database of buildings included in the Topographic Object Data Bank (Pol. *Bank Danych Obiektów Topograficznych* BDOT10k), updated in 2015.

The analysis of spatial concentration of sports infrastructure buildings makes it possible to identify areas within spatial units, including cities, that have the potential to function as "sports-cities."

The authors believe that results obtained in this way may prove helpful when analysing the attractiveness of a given space for practicing sport, and also when determining tourist attractiveness for the purpose of urban and sports tourism.

The novelty of the study is associated with the use of orthodromic distances[2] between apartment buildings and sports infrastructure buildings. So far in the literature of the subject there has been no comprehensive study involving the calculation of dispersion coefficients for these distances or any attempts to use such coefficients to determine areas of concentration of a given function in space. The article fills this research gap.

2. Literature review

2.1. The notion of a sports city

Different names are used in the literature to refer to places for practising sports in the city. For example, the concept of a sport city is used in the following three different ways [Pye, Cuskelly, Toohey 2016: 375] depending on the situation: (1) creating a temporary sports attraction, (2) allocating part of the city for sporting activities, (3) creating a brand of the entire city.

Other names include "sport hub", "international sports village," "sports zone," "national cities of sport" [Pye, Cuskelly, Toohey 2016: 375]. Pye et al. define the city of sport as a city that uses sport visibly in public policy, in developing infrastructure, in creating its image and brand. [Pye, Toohey, Cuskelly 2015]. Analysing the value of sport-city zones Smith explains their significance as "physical sports-city zones – concentrated sites of sports facilities that are developed as merely one part of a city" [Smith 2010: 386]. J. Berbeka uses the concept of "sport cities" referring to the theory of M. Sorkin regarding "theme parks" [Sorkin 1992] and defines them as separated, large areas of space in which the buildings are associated with sport and recreation, and because of their complexity, are called sports-city [Berbeka 2013: 5].

[2] Also known as the great-circle distance, is the shortest distance between two points on the surface of a sphere. The name is derived by combining two Greek words *orthos* – straight and *dromos* – line, road [Szpytko, Hyla 2007].

2.2. Components and types of sport cities

Sport appears in urban space either in the simplest form, following the appearance of a single sports facility or in the form of complexes of facilities with various functions, combining sport with entertainment and trade [Berbeka 2013: 10-11].

One example of a place in Poland that brings together a large number of functionally complementary sports infrastructure facilities is the area around the Malta Lake, which is the location of the largest recreation and sports complex in the Poznań agglomeration, featuring cross-country tracks, bike paths, a ski slope, an ice rink, a summer toboggan run, hotels and restaurants [Motek Kossowski, Bogacka 2010]. Since 2011, Poznan residents have been able to visit Termy Maltańskie, the most modern and largest water sports and recreational complex in Poland, which boasts an Olympic-size swimming pool.

Sports zones may feature various sports and sport-related facilities. Based on examples mentioned by Berbeka [2013: 10-13] the following list of sports and recreational facilities can be found in a sport city:

– a single major sports facility (e.g. a tennis court, ice rink, football arena),

– minor facilities related to the same sport discipline or designed for different disciplines that broaden the possible forms of engaging clients' free time at the site,

– additional infrastructure in the vicinity of sports facilities (catering, retail outlets, hotels),

– sports museums as a tourist attraction that meets the needs in the field of nostalgia sports tourism,

– other facilities functionally supporting the initial sport function (e.g. a hospital specialising in the treatment and rehabilitation of athletes, educational units specialising in sports education).

Smith [2010: 386] indicates that the sports-focused specialization of certain urban zones has a long history, as exemplified by Olympia in Ancient Greece (around 700 BC) and nineteenth-century British cities. He also tracks the process of their evolution from places that cater for the needs of local residents only to zones that also attract outsiders (tourists and new residents). Smith [2010: 387] distinguishes certain types of sport zones based on how they were created:

– sport zones created spontaneously as concentrations of activities of a given type in an organic (bottom-up) manner,

– zones created as a result of promotional activities of the city/district aimed at attracting e.g. a tourist and the creation of proper image of sport city/zone,

– zones resulting from the process of planned development of a specific space/district aimed at achieving the target theme (e.g. sport theme),

– zones created by redevelopment of places or infrastructure created in the past for the purpose of sporting events.

Smith presents a set of contemporary examples of places that can be regarded as spatially specialized sport zones. He describes, among others [Smith 2010: 388-395]:

– an area designated as part of urban space co-created by firms or media institutions (i.e. ESPN Wide World of Sports Complex; ESPN Zones in New York, Washington, Baltimore and Chicago, Nike Towns),

– a commercial sports centre, often located outside of the urban area, considered to be a supra-local attraction (i.e. La Manga club in Spain),

– a complex, whose creation was inspired by a great sports event (Olympic Village in the Olympic Park in Munich transformed into a recreation centre),

– a place created from scratch in a comprehensive way to generate tourism demand (The SportCity in Manchester, International Sport Village in Cardiff, The Aspire Zone in Doha in Qatar, Sports City in Dubai).

2.3. Functions and effects of sport cities

While individual sports facilities tend to attract local residents, for whom accessibility (short distance) to the facility is an important factor, sport facilities complexes may acquire a supra-local importance and attract users from more distant areas. They can cause an increase in tourism demand, improve the tourism potential of the city and become linked with other elements of the urban tourism product in a given agglomeration. [Harrison-Hill, Chalip 2005 as cited in Berbeka 2013: 15]. At least, these outcomes are expected by creators or investors involved in the development of such places.

Smith [2010] points out that the clustering of sports facilities can also have positive effects on local producers of sports services who facilitate access to a wider stream of consumers, specialized knowledge and qualified workforce. This view is in line with Brown, O'Connor and J. & Cohen [2000 as cited in Smith 2010], who compares specialized districts to industrial districts of so called Third Italy [Becattini 1990]. Entities that operate in such places derive benefits from the positive effects of geographical and sectoral agglomeration, such as external economics described by Marshall [1920 as cited Alberti 2002: 17].

Because of their attractiveness, sport cities may:

– attract major sports events (and also demand from sports tourism),

– attract athletes looking for training facilities,

– attract city residents looking for places to engage in active recreation.

The city's ability to attract sport participants is determined by the following factors [Smith 2010: 407]:

– the comprehensive character of the sports offering (variety and multi-functionality of facilities),

– the comprehensive character of services that support sports activity (accommodation, SPA facilities, commercial, health, educational and entertainment functions).

– the degree of integration of a sports city with existing "traditional" tourist attractions (e.g. local urban tourism, which can create an additional synergistic effect).

There is an important discussion in the literature concerning the question of whether the construction of sports infrastructure and sport city zones creation is an effective tool for the development or revitalization of the city and its space. Smith points to the danger of creating an artificial place, a kind of "sport-anchored tourist bubble", isolated from the rest of the city, which, while providing entertainment and recreation for visitors, does not necessarily bring benefits to ordinary residents of the city [Smith 2010: 394].

Friedman, Andrews and Silk [2004] describe the exact mechanism of such an unfortunate series of events related to the revitalization processes of Baltimore, where large amounts of public money spent on developing exceptional sports and recreation infrastructure did not contribute to improving the living conditions of its residents. Chapin [2004], who also described the case of Baltimore, argues that investments in large sports facilities have no economic justification, but admits that they are an effective tool for the regeneration of urban districts. Austrian and Rosentraub [2002] share this view and provide evidence showing that focusing on the development of the sport and tourism sector as a tool of urban regeneration actually restores some aspects of economic development to these places. However, they still believe that two problems remain: (1) the total cost of such policies and (2) the cost of lost opportunities resulting from focusing on one path of development. Turner and Rosenbaum also describe the process of redeveloping urban districts in crisis cities through the development of sports infrastructure and they point to the gap between the costs and benefits for the city and residents [Turner, Rosentraub 2002]. Similar conclusions are drawn by Coates and Humphreys [2003] who, after critically reviewing the debate in the literature on the role of professional sport in the processes of economic revitalization of cities (with a professional sports team and infrastructure), state that economists have not yet found evidence for a positive relationship.

To sum up, creating "city of sport" complexes often requires relatively large investments that are prone to various risks. Decisions concerning their implementation must be preceded by a comprehensive (economic and social) analysis and have a strategic nature [Berbeka 2013: 20].

Mason [2016] formulates a similar assessment. In his view, the decision to use the sports infrastructure as the core of downtown development processes should be based on the assumption that the most attractive and competitive cities are those that carefully integrate sport and entertainment facilities as part of broader development initiatives and which use other unique features that these cities already have.

Development strategies in this area should be combined into packages to create a synergy effect in order to allow cities and their stakeholders to prosper and gain a competitive advantage.

2.4. Identification of the potential of sport districts/zones in the literature

No previous studies of the distribution of sports zones in territorial units and of their attractiveness have not been carried out using the tools proposed by the authors of this article.

Of course, the sport infrastructure in Poland has been the subject of research. Studies in this regard have been reviewed by, among others, Kopacki and Bogacka [2017]. They highlighted examples of stocktaking and descriptive studies, as well as those regarding various specific aspects such as finances, functionality, renovation needs for specific types of sports facilities [MSiT 2015a, 2015b, 2016a, 2016b].

From the point of view of the problem addressed in this article, studies involving spatial analysis of the sport infrastructure are particularly relevant. A number of studies can be listed in which analysis focuses on the distribution of objects in communes [MSiT 2015b] or in particular provinces [Chudy 2012, 2013]. Similar examples include a study of sports infrastructure in the Poznań agglomeration by Motek, Kossowski and Bogacka [2010] or the work of Mamcarczyk [2018] where the problem is analysed at the level of provinces (first-tier units) and communes (third-tier units) in the district of Wadowice (second-tier unit). The results were expressed in terms of infrastructure indicators per unit of administrative division. They cannot be used to make conclusions about the existence of specialized sports zones at commune level.

Other studies in which a single city is the unit of analysis include the work of Turczyn regarding Łódź [Turczyn 2003] and the study by Kowalski concerning Cracow [Kowalski 2011]. Both authors tried to identify the existing infrastructure and assess its availability to local residents. However, their studies are not based on objective indicators, but on the authors' subjective assessments in which they attempted to determine whether sports facilities evenly complement the residential function of the city space. A different approach to the analysis of the distribution of sports infrastructure in urban space is taken by Łobodzińska and Kowalski. Their study offers a historical view of how sport functioned in the urban space of Cracow, Łódź and Wrocław during the socialist period [Łobodzińska, Kowalski 2015]. Their analysis is also based on a subjective assessment of the distribution of sports activity but the authors recognise the existence of axes or cores of concentration of the sports infrastructure.

There are analyses devoted to the availability of the sports infrastructure. Cieplik and Sołtysik [2012] analyse transport accessibility of recreation areas in Wrocław; Wiśniewski [2016] examine spatial accessibility of water parks in Łódzkie province; Kopacki, Bogacka [2017] present characteristics and transport accessibility of selected academic sports halls in Poznań using data from a transport application [jakdojade.pl].

Studies of the sports infrastructure in cities are also present in the world literature. They focus on the sport or recreational potential of entire cities, which enable comparisons between various urban centres [cf. Liu et al. 2019].

Nonetheless, the literature lacks studies devoted to the distribution of the sports infrastructure in non-aggregated space into administrative units, especially ones that rely on objective methods of economic and spatial analysis. This kind of approach may provide better possibilities of identifying specialized sports and recreation zones within specific spatial units, which cannot be identified at higher (i.e. commune) level.

Economic and spatial analyses based on the shortest Euclidean distances have a long tradition. They were already used at the beginnings of the 20th century by J. Czekanowski for purposes of taxonomic analysis or as the basis for the deduction conducted by the research team consisting of K. Florek, J. Łukaszewicz, J. Perkal, H. Steinhaus and S. Zubrzycki [Heffner, Gibas 2007]. At the beginning of the 1970s, B. Kostrubiec developed the Shortest Dendrite Method (Pol. *minimalne drzewo rozpinające* – MDR) based on the Euclidean distance [Kostrubiec 1972], which in the English literature is known as the minimum spanning tree (MST) method and, according to R. L. Graham and P. Hell [1985], is associated with such surnames as Borůvka, Kruskal and Prim. This method has grown in importance after its application in the graph theory, carried out by R. N Mantegn in 1999 [cited in Sharif, Djauhari 2016], and consequently in the GIS software as part of network analysis. It should be noted that spatial measures based on the shortest distance are also used in urban pattern dispersion tests [Reis, Silva, Pinho 2016; Herold, Couclelis, Clark 2003; Gibas 2017; Gibas, Heffner 2018a].

3. The research method

The empirical part of the article describes the process of identifying sport zones in Poland using the spatial dispersion indicator of residential buildings in relation to sports infrastructure buildings.

In order to perform this process the following hypotheses were formulated:

H1. A sport zone as a product of urban tourism (sports tourism) is an area characterized by high values of indicators measuring the concentration of recreation and sports infrastructure.

The attractiveness of areas for performing sports activities could be measured in terms of the concentration of sports infrastructure facilities present in a given area. The measure of concentration shows the density of sports facilities within the sport zone in comparison to the neighbouring area.

H2. A sport zone as a product of urban tourism is characterized by relatively low distances between sport facilities and residential buildings.

The second hypothesis addresses problematic sport zones which are sometimes created in a more artificial manner and are relatively isolated from areas where the majority of the city's inhabitants live. Both public and private entities should attempt to achieve a maximum engagement of local residents in the sport zone. Therefore, the proximity between sport facilities in the sport zone and residential buildings is a desirable feature.

To verify the hypotheses, the authors used objective measures of concentration and dispersion of sports infrastructure buildings obtained from the analysis of the centroid database of buildings included in the Topographic Object Data Bank (Pol. *Bank Danych Obiektów Topograficznych* BDOT10k).

The calculations were based on centroids over 14.7 million buildings that constitute one of the layers of the Topographic Object Data Bank (BDOT10k[3]) according to the 2015 update. Centroids were determined using the QGIS software (ver. 2.14.3 Essen[4]). The area of the whole country was analysed at the level of communes (based on the National Administrative Border Register). It should be noted that the distribution of buildings in Poland is based on the functional classification of communes proposed by P. Śleszyński and T. Komornicki [2016].

The basic analytical procedure was aimed at determining orthodromic distances (shortest Euclidean distances) between over 7 million apartment buildings and 5.4 thousand buildings used for sport-related purposes (sports halls, sports clubs, gyms, swimming pools, shooting ranges, riding schools, indoor tennis courts). Orthodromic distances between centroids (point representations) of buildings were used to determine the dispersion coefficients [see among others: Reis, Silva, Pinho

[3] The structure of the database is described in the following source: *Opis bazy danych topograficznych i ogólnogeograficznych oraz standardy techniczne tworzenia map. Załącznik do rozporządzenia Ministra Spraw Wewnętrznych i Administracji z 17 listopada 2011 r. w sprawie bazy danych obiektów topograficznych oraz bazy danych ogólnogeograficznych, a także standardowych opracowań kartograficznych*, t. I, Dz.U. załącznik do nru 279, poz. 1642 27 grudnia 2011 r., more information on how this database was created: Olszewski, Gotlib (eds.) 2013.

[4] Possibilities of using GIS to assess retail locations are analysed by Murad [2015].

2016; Herold, Couclelis, Clark 2003; Gibas, Heffner 2018b] defined as the arithmetic mean of the shortest Euclidean distances.

Locations of sports facilities were also subjected to the procedure of nuclear density estimation (KDE), with a 10-fold radius change (from 1 km to 10 km to 1 km). The results of this procedure were used to objectively identify concentration zones of sports infrastructure buildings and describe the relationship with estimation coefficients using linear and exponential regression functions.

A peripheral location in this study refers to the population of a given commune living in a place located further away from sports facilities than the typical orthodromic distance, defined as the average distance plus its standard deviation. Unfortunately, the available Polish statistical and official data cannot be made available for formal reasons, which is why the study uses a model of population distribution developed by P. Gibas in the Department of Spatial and Environmental Economics of the University of Economics in Katowice. The model is based on the estimated gross internal area and location of residential buildings as well as population statistics as at December 31, 2015. The resulting model estimates the number of inhabitants living in individual buildings. The average value of the model error (underestimation) is 2 people with a median of 0 and a standard deviation of 33 people. For 25% of municipalities in Poland, the underestimation is up to 14 people, while in the case of another 25% the overestimation exceeds 12 people. The maximum underestimation is 366 people, while the maximum overestimation of the number of people living in a given commune is 568. The modal overestimation for communes is 2 people. The model parameters were therefore considered sufficiently good to be used as the basis for further calculations.

4. Results

According to the Topographic Object Data Bank (BDOT10k), in 2015 there were 5.4 thousand buildings used for sport-related purposes (0.04 percent of all buildings) in Poland. The biggest group included sports halls (1.6 thousand – 30.31% of all sports facilities), followed by sports clubs (1.4 thousand – 26.26%), gyms (1. thousand – 18.56%) and swimming pools (0.7 thousand – 12.24%). The share of other types of sports facilities was below 2.5 percent, of which the most numerous were shooting ranges (113 – 2.09%), riding schools (87 – 1.61%) and tennis courts (86 – 1.59%). Other types of buildings used for sport-related purposes included, for example, entertainment halls (140 – 2.59%) and secondary schools (37 – 0.69%).

Sports buildings in the dataset are most often located in urban cores of functional areas of provincial capital cities (type A) (1.2 thousand – 21.87%). A rela-

Table 1. Descriptive statistics of distances between sport buildings in communes by functional category

Functional category	Number of buildings	Percentage of sport buildings	Average distance between sport buildings in meters (dispersion factor)	A standard deviation of the distance in meters
A – cores of functional areas of provincial capital cities	1181	21.87	2361.97	10 868.54
B – external zones of functional areas of provincial capital cities	705	13.06	1021.44	1 296.39
C – cores of functional areas of sub-regional cities	644	11.93	1630.17	2 327.39
D – external zones of sub-regional cities functional areas.	355	6.57	931.23	1 191.55
E – functional areas of medium-sized towns including smaller towns with special functions, e.g. tourist centres and resorts.	674	12.48	1328.07	1 539.92
F – communes with a developed transport function	207	3.83	1012.02	1 907.49
G – communes with well-developed non-agricultural functions (tourism and surface mining industry)	345	6.39	1241.83	1 595.89
H – communes with a well-developed agricultural function.	365	6.76	822.26	857.44
I – communes with a moderately developed agricultural function	677	12.54	865.07	887.23
J – communes with relatively extensive areas designated for purposes of forestry or nature protection	247	4.57	897.32	994.68

Source: own elaboration based on the functional classification by Śleszyński and Komornicki [2016].

tively large percentage of these buildings (over 10%) can also be found in external zones of urban functional areas of provincial capital cities (type B) (0.7 thousand -13.06%), in cities – multifunctional centres (type E) (0.7 thousand – 12.48%) and cores of functional areas of sub-regional cities[5] (type C) (0.6 thousand – 11.93%). With regard to rural communes, most sports facilities are located in

[5] A detailed definition of this category can be found in Śleszyński and Komornicki [2016].

communes with a moderately developed agriculture (type I), (0.7 thousand – 12.54%) (see Table 1).

Moving on to distances between residential buildings and buildings used for sport purposes, the average distance is slightly above 5 km, with a standard deviation of 3.5 km. The median distance is 4 km, with a quarter of municipalities where the median distance is less than 2.6 km, and three quarters, where it is less than 6.9 km.

In terms of distance from residential building, sports facilities in large cities (Warsaw, Cracow, Wrocław, Poznań to name a few) are most easily accessible. Analysing the spatial distribution of distances, it is noteworthy that lower ranges of variability (distances below the average) can be found over a much larger territory than upper ranges of variability (distances above the average). Communes for which the distances are below the average are located, among others, in significant areas of Śląskie, Małopolskie, Świętokrzyskie and Podkarpackie (with relatively few exceptions). Large or very large distances between residential and sports buildings are found in municipalities located in areas along the borders between Zachodniopomorskie and Pomorskie, as well as Mazowieckie, Podlaskie and Lubelskie (see Fig. 1).

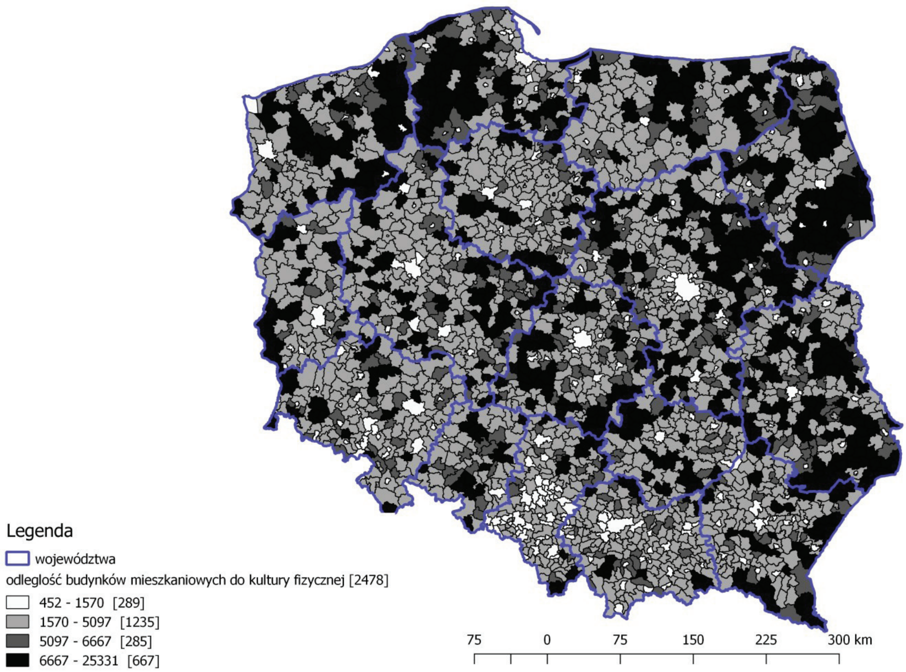

Fig. 1. Distance intervals (in meters) between residential buildings and sports facilities in communes (lower limit – upper limit [number of communes])

Source: own elaboration.

The smallest average distances between residential and sports buildings exist inside cores of functional areas of provincial capital cities (type A) with an average distance of 1.2 km (standard deviation of approx. 1 km); distances between both types of buildings inside cores of functional areas of sub-regional cities (type C) are on average equal to 1.3 km (standard deviation of about 1 km), in multifunctional centres (type E) the average distance is 1.8 km (with standard deviation of 1.9 km). The longest distance were recorded in communes with a well-developed agricultural function (type H) (the dispersion factor of 6.1 km, with standard deviation of 4.2 km) and communes of type J – 6 km and 4.6 km, respectively (see Table 2).

Given that the number of sports buildings located in rural areas is relatively small and they are mostly concentrated in large cities, the analysis of shortest distances between sports and residential buildings revealed that 1,067 Polish communes are not affected by the problem of a peripheral location in relation to sports buildings. In the remaining communes, the median orthodromic distance between residential and sports buildings was up to 2.2 km, with a maximum of 18.9 km.

Across all those communes including peripheral locations (1412), on average, 31.59% of the population lives in areas where the orthodromic distance to sports buildings is bigger than the typical one (with the standard deviation of 33.34%). The median share of the population living in peripheral locations is 15.63%, while the first quartile is just 3.62%. For three-quarters of communes, the percentage of population living in buildings located at least at a typical distance[6] from sports buildings is below 58.06, although there are some communes where 100% of the population lives in peripheral locations.

When analysing peripheral locations associated with access to sports buildings, attention should, first of all, be paid to provinces or parts thereof least affected by this problem. These include Śląskie, Małopolskie and Dolnośląskie, but also to significant parts of Podkarpackie, Świętokrzyskie, Wielkopolskie, Kujawsko-Pomorskie, Łódzkie and Mazowieckie. This, of course, is related to sports buildings located in the cores of metropolitan (less often regional) cities. An interesting spatial distribution is also characteristic of communes whose percentage is above the value of the third quartile. These communes are located mainly in the central and eastern part of Zachodniopomorskie and in the western and central part of Pomorskie. Another belt of such areas extends from the northern part of the Warmińsko-mazurskie, through the eastern part of Podlaskie and Mazowieckie to the eastern outskirts of Lubelskie and Podkarpackie. However, it should be noted that in most cases, these strips are interrupted by communes

[6] The average distance plus its standard deviation.

Table 2. Descriptive statistics of distances between residential and sports buildings across communes by functional category

Functional category	Minimum distance between sport buildings in meters	Maximum distance between sport buildings in meters	Average distance between sport buildings in meters (dispersion factor)	Standard deviation of the distance in meters
A – cores of functional areas of provincial capital cities	4.48	11 648.20	1260.15	1021.80
B – external zones of functional areas of provincial capital cities	5.12	20 620.10	3044.18	2534.38
C – cores of functional areas of sub-regional cities	7.65	8612.59	1322.12	1027.44
D – external zones of sub-regional cities functional areas.	12.82	20 289.60	3498.16	2477.35
E – functional areas of medium-sized towns including smaller towns with special functions. e.g. tourist centres and resorts.	8.39	14 043.50	1839.61	1944.93
F – communes with a developed transport function	11.45	25 789.20	4708.60	3862.43
G – communes with well-developed non-agricultural functions (tourism and surface mining industry)	11.51	26 505.60	5001.34	4118.77
H – communes with a well-developed agricultural function.	5.04	27 520.10	6131.32	4166.51
I – communes with a moderately developed agricultural function	10.65	24 756.70	5577.84	3841.45
J – communes with relatively extensive areas designated for purposes of forestry or nature protection	13.30	24 860.00	6064.73	4576.59

Source: own elaboration.

with a lower percentage of residents living in peripheral locations in relation to sports buildings. (see Fig. 2).

Returning to the issue of spatial concentration of sports facilities, interesting insights can be drawn from the analysis of kernel density indicators calculated for areas with a radius of 5 km (see Fig. 3). The map complements the previous analyses showing places within cities and rural areas that are characterized by a significant saturation of sports facilities. Major metropolitan agglomerations

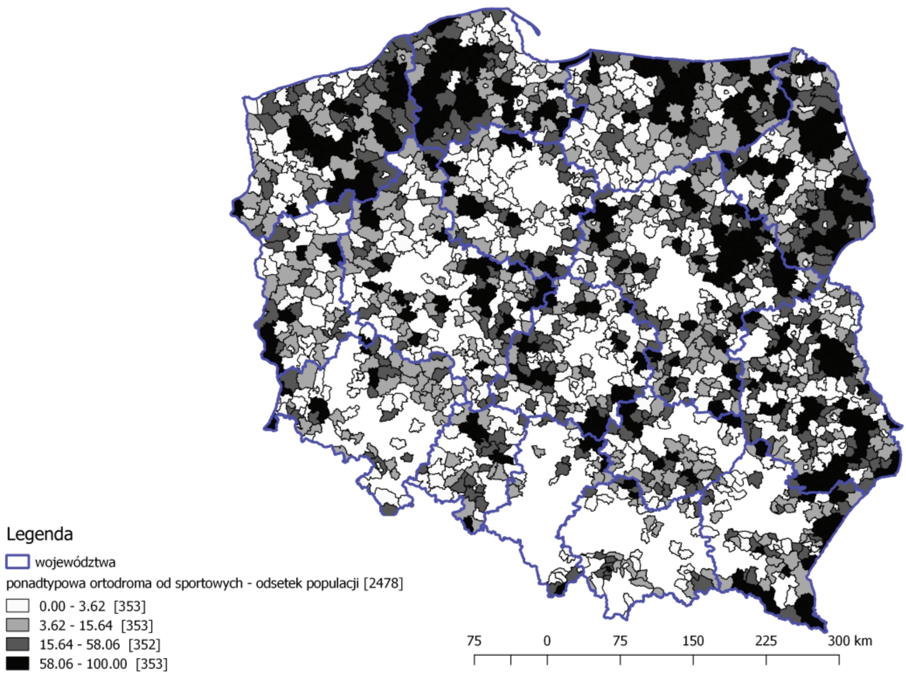

Fig. 2. Quartiles of communes grouped by range of the population share living in areas with non-typical distances from sports buildings (lower limit – upper limit [number of communes in the quartile])

Source: own elaboration.

(red and orange) stand out, but areas located in smaller communes (blue and green) are also visible.

On the basis of the statistical parameters of linear and exponential regression estimators it can be concluded that the cores of functional areas of provincial capital cities have the highest spatial concentration of sports buildings (type A – mean linear estimator of 0.88264 and mean exponential estimator of 0.0200). Linear estimators also indicate the density of sports buildings within cores of functional areas of sub-regional cities (type C: average estimator = 0.7529), external zones of functional areas of provincial capital cities (type B: average estimator = 0.7414), external zones of functional areas of sub-regional cities (type D: average estimator = 0.7279) and other multi-functional cities (type E: average estimator = 0.7008. Interestingly, cities with multifunctional areas and cores of functional urban areas of subregional cities are also characterised by larger than average values of exponential estimators of the kernel density function (for type C, it is 0.0186 and for type E – 0.0175), which means that sport zones are located mainly in cities (see Table 3 and 4).

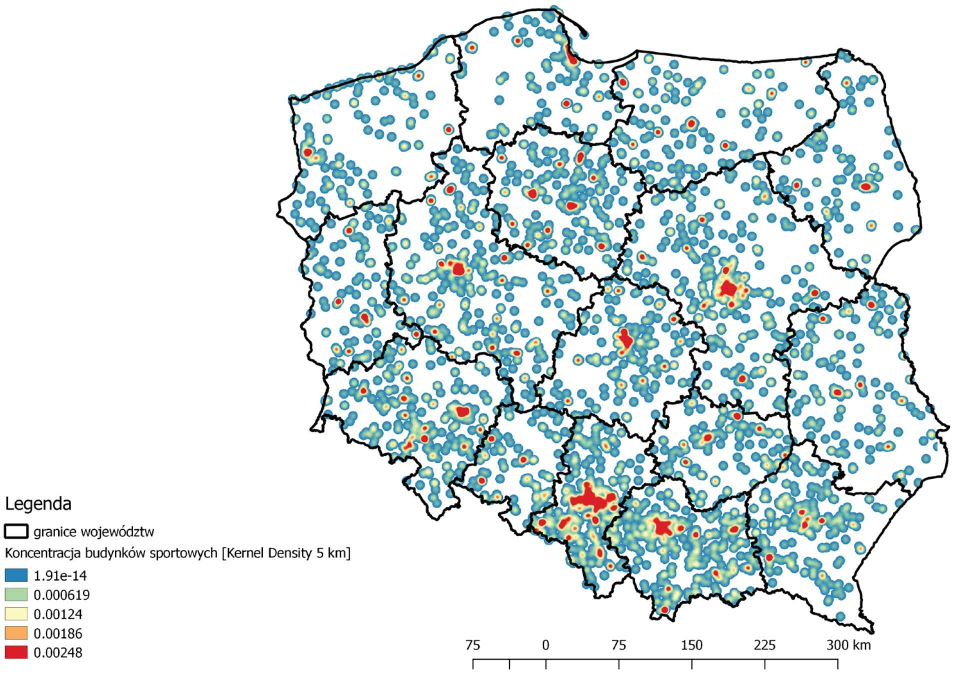

Fig. 3. Concentration of sports buildings in areas with a radius of 5 kilometres (KDE – kernel density estimation)

Source: own elaboration.

Values of the average linear estimator of the kernel density function for communes were divided into the following classes using the Jenks optimization method: dark purple – 72 communes (0.8051 to 0.9345), purple –168 communes (0.74760 to 0.8051), light purple – 274 communes (0.7006 to 0.7460), light green – 408 communes (0.6592 to 0.7006) and dark green – 559 communes (0.613 to 0.6592). The average estimator can also be used to identify communes with the biggest change in kernel density indicators, given their exact location determined by the granularity of estimation (see Fig. 4).

5. Conclusions

The main purpose of this article was to define the concept of an urban sport city zone and to identify such zones as a potential product of sports tourism in Poland using the spatial dispersion indicator of residential buildings in relation to sports

Table 3. Statistical parameters of the linear regression estimator of the kernel density function (KDE)

Functional category	Minimum estimator	Maximum estimator	Average estimator	Standard deviation of the estimator
A – cores of functional areas of provincial capital cities	0.6313	1.0209	0.8264	0.0673
B – external zones of functional areas of provincial capital cities	0.6313	0.9605	0.7414	0.0681
C – cores of functional areas of sub-regional cities	0.6313	0.9294	0.7529	0.0544
D – external zones of sub-regional cities functional areas.	0.6313	0.9154	0.7279	0.0664
E – functional areas of medium-sized towns including smaller towns with special functions. e.g. tourist centres and resorts.	0.6313	0.9886	0.7008	0.0469
F – communes with a developed transport function	0.6313	0.8581	0.6960	0.0533
G – communes with well-developed non-agricultural functions (tourism and surface mining industry)	0.6313	0.8588	0.6824	0.0445
H – communes with a well-developed agricultural function.	0.6313	0.8778	0.6708	0.0428
I – communes with a moderately developed agricultural function	0.6313	0.9228	0.6829	0.0500
J – communes with relatively extensive areas designated for purposes of forestry or nature protection	0.6313	0.8440	0.6787	0.0480

Source: own elaboration.

infrastructure buildings. The analytical part of the article shows the distribution of sports infrastructure buildings in Poland (across communes classified by functional category) and also it indicates concentration zones at commune and intra-commune level.

The authors believe that the proposed research method and its results could help to identify sport-city zones in urban spaces and to evaluate their ability to attract residents and visitors (also tourists). The objective indicators could be used to determine whether there are places/zones/complexes that could be categorised as “sport cities” or whether there is an infrastructural potential for the

Table 4. Statistical parameters of the exponential regression estimator of the kernel density function (KDE)

Functional category	Minimum estimator	Maximum estimator	Average estimator	Standard deviation of the estimator
A – cores of functional areas of provincial capital cities	0.0021	0.0999	0.0200	0.0173
B – external zones of functional areas of provincial capital cities	0.0024	0.0658	0.0115	0.0113
C – cores of functional areas of sub-regional cities	0.0024	0.0691	0.0186	0.0132
D – external zones of sub-regional cities functional areas.	0.0025	0.0404	0.0088	0.0072
E – functional areas of medium-sized towns including smaller towns with special functions. e.g. tourist centres and resorts.	0.0032	0.0608	0.0175	0.0115
F – communes with a developed transport function	0.0028	0.0493	0.0084	0.0058
G – communes with well-developed non-agricultural functions (tourism and surface mining industry)	0.0029	0.0710	0.0120	0.0130
H – communes with a well-developed agricultural function.	0.0032	0.0598	0.0096	0.0100
I – communes with a moderately developed agricultural function	0.0031	0.0531	0.0085	0.0067
J – communes with relatively extensive areas designated for purposes of forestry or nature protection	0.0028	0.0364	0.0080	0.0060

Source: own elaboration.

existence of such places. The method could also help to identify places where the development of a sports-city is promising and the investment in sports and sport-related infrastructure is justified.

The proposed research method could prove helpful for both private and private sector entities to make investment decisions. It is based on two assumptions (hypotheses).

According to the first hypothesis (H1), a sports zone as a product of urban tourism (sports tourism) is an area which is characterized by high values of the concentration indicators of recreation and sports infrastructure.

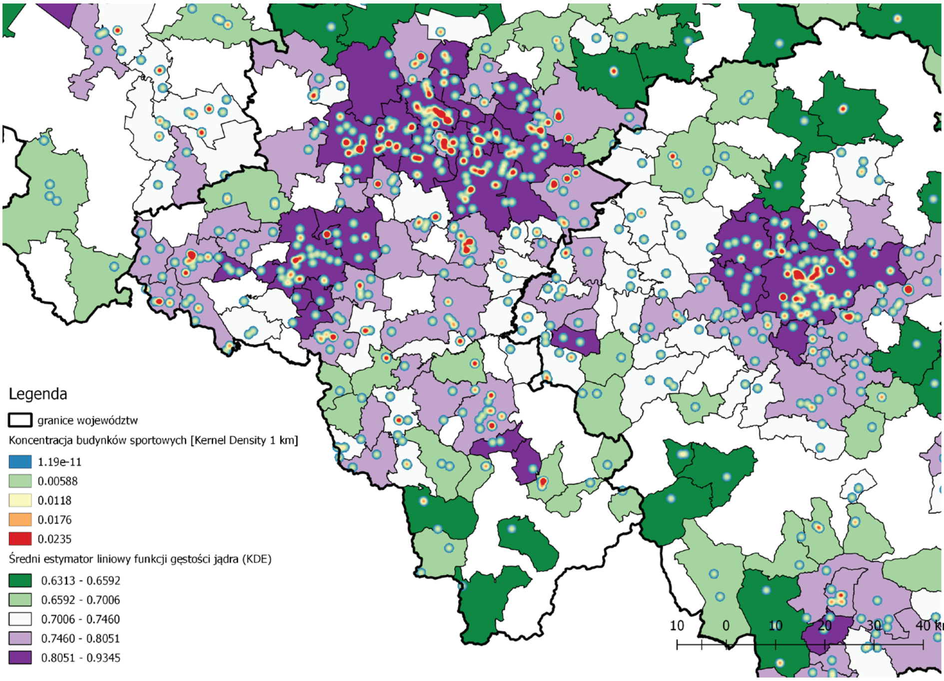

Fig. 4. Concentration of sports buildings in areas with a radius of 1 km (KDE – kernel density estimation) superimposed on the average linear estimator of the kernel density function

Source: own elaboration.

To verify this hypothesis, locations of sports buildings were analysed using kernel density estimation (KDE) to objectively identify concentration zones of sports infrastructure buildings. The measure shows the concentration of sports building inside sport zones in comparison to the neighbourhood. The results obtained from the analysis could be used in different ways by the public and the private sector. Insights for the public sector could help to:

– evaluate communes in terms of the presence of sports infrastructure,

– evaluate different variants of investment strategies in sport facilities and spatial management,

– identify sport zones/sports cities defined as concentrations of sport infrastructure that is already present at the site (in a commune or part of a commune),

– identify sport zones which have the potential to attract both type of visitors (residents performing proximity tourism) and visitors from outside (sports tourism),

– identify underdeveloped places lacking sports infrastructure.

Insights from concentration analysis for the private sector could help to:

– evaluate locations in terms of the intensity of competition (especially when the first mover strategy is considered),

– evaluate locations in terms of the presence of desirable critical mass of different sport and recreational facilities which could make the site attractive not only for local residents but also for other visitors (this information could be used to evaluate the investment in complementary sport or recreational facilities and probability of business success).

Dispersion coefficients were used to validate the second hypothesis (H2): "A sports zone as a product of urban tourism should be characterized by relatively low distances between sport facilities and the residential buildings". The results obtained from the analysis could be used in different ways by the public and the private sector. Insights for the public sector could help to:

– estimate the number of local residents living close to a certain sport zone site (existing or planned),

– evaluate potential engagement of local residents in activities in the sport zone and therefore the potential utility of the sport zone for the local community,

– evaluate the risk of creating problematic sport zones which are sometimes created as artificial places that are isolated from local residents.

Information about dispersion coefficients could be useful for the private sector because:

– it gives an indication of potential local demand for planned commercial service points,

– it can be used to evaluate and compare possible locations of service points taking into account the number of local residents living in the vicinity.

Encouraging local residents to take advantage of the sport zone should be the goal for both the public and the private entities. This is why they should be interested in evaluating the proximity between sport facilities in the sport zone and local residential buildings.

In conclusion, the above analysis may help to detect sport zones using just one criterion: the indicator of spatial dispersion and selected quantitative methods. The analysis is a preliminary detection of potential locations of sport zones. It could help to identify places which have the potential to attract visitors performing sports tourism. More accurate research, using additional criteria (e.g. the use of qualitative research) may improve the accuracy of the analysis.

The results of the study could provide valuable input for sport service providers and their consumers in the process of making spatial decisions. They can also contribute to the understanding of spatial behaviour of local actors involved in the creation of the sports services market and those affected by the external effects (both positive and negative) generated by the sports infrastructure.

The proposed method could be improved by exploiting detailed information about buildings, which could be used to differentiate them in terms of their significance. This information about the "weight" of the building (e.g. through the use of qualitative research) would enrich the analysis by providing more rational grounds for choosing locations and for consumer decisions.

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Identyfikacja miejskich stref sportu jako potencjalnego produktu turystyki sportowej przy użyciu metody wskaźników dyspersji przestrzennej

Streszczenie. Celem artykułu jest zidentyfikowanie miejskich stref sportu (nazywanych w literaturze miastami sportu) jako potencjalnego produktu turystyki miejskiej lub turystyki sportowej z wykorzystaniem wskaźnika rozproszenia przestrzennego budynków mieszkalnych w odniesieniu do budynków infrastruktury sportowej w Polsce. Ortodromy (najkrótsze odległości euklidesowe) między budynkami mieszkalnymi (ponad 7 mln budynków) i budynkami związanymi z funkcją kultury fizycznej (5,4 tys.) zostały obliczone z wykorzystaniem centroidów wyznaczonych przy użyciu danych budynków zawartych w banku danych obiektu topograficznego (BDOT10k). Ortodromy posłużyły do określenia współczynnika dyspersji, który pozwala na wskazanie stref koncentracji budynków infrastruktury sportowej. W rezultacie zaprezentowano dystrybucję budynków infrastruktury sportowej w Polsce oraz ustalono strefy koncentracji budynków infrastruktury sportowej (przy użyciu gmin jako bloku funkcjonalnego). Pozwala to odróżnić obszary mające potencjał, aby być miastem sportu, to jest złożonym, oddzielnym, dużym obszarem przestrzeni, którego rozwój jest związany ze sportem i rekreacją.

Słowa kluczowe: turystyka sportowa, rozproszenie przestrzenne, BDOT10k, miasto sportu, strefy sportowe, turystyka miejska