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Cycling Trail Network of the Poznań Metropolital Area: Prospects for Research in Physical Activity and Recreational Appeal[1]

Abstract. The increased popularity of cycling in Poland has given new prospects for interdisciplinary research. This enabled multifaceted analysis of recreational activity based on a network of bike trails. One such well-functioning and well-managed network is the Wielkopolska System of Bike Trails which is especially popular in the Poznań agglomeration. The aim of this paper was to present pre-developed methods for analysing a network of bike trails in terms of physical activity and recreational attractiveness as well as to present preliminary results concerning an exemplary trail. The obtained results will enable further development of the methods in order to quite a vague statement make them more precise. Then, the methods will be used to analyse a landscape, trails, and cyclists in order to create a targeted tourist and recreational offer for the Poznań agglomeration based on the Wielkopolska System of Bike Trails.

Keywords: bike active, bike tourism, bike trails, Poznan agglomeration

1. Introduction

Recreational and tourist cycling in Poland has become more and more popular among Polish and foreign tourists. Poland has been accounted to one of the ten countries in Europe where the expenses on bicycle tourism are the highest (abo-

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ut EUR 2 billion per annum). It is an attractive area, especially for tourists from Southern Europe. Experts also indicated the proximity of the German market as beneficial because it generates the highest revenue from this type of tourist activity (almost EUR 11.4 billion) [Dembińska 2016]. Moreover, the European Cyclist Federation, which cites a study commissioned by the European Parliament in 2012, estimated that there are over 2.2 billion cycle tourism trips and 20 million over-night cycle trips made every year in Europe. These have an estimated economic impact of EUR 44 billion.

The Wielkopolska Region now plays a very important role in using its own bicycle potential, especially in the subject of marking out bike trails. *Wielkopolska System of Bike Trails* exists since 2001 and consists of 9 trails of the total length of 1800 km. Borawska-Melnyk [2016] suggested that creating attractive and high-quality trails with a rich variety of accommodation and gastronomic choices in environmentally and culturally valuable areas is an important factor influencing development of bicycle tourism. Analysing the stage of bicycle tourism development in the agglomeration and cyclists' opinions are especially important issues that should be taken into consideration in proper development of the infrastructure. Current problems of bike trails in the Wielkopolska Region (including the Poznań agglomeration) were discussed during a professional conference entitled "Bicycle tourism in the Wielkopolska Region" which was organised by the Office of the Marshal of the Wielkopolskie Voivodeship on 21 October 2016.

This paper aims to determine the prospects for research in physical activity and recreational attractiveness of bike trails in the Poznań agglomeration. It is based on a pilot study into served a purpose of verification of the assumptions and their specification what will enable conducting proper multifaceted analysis in further research.

2. Research on cycling in urbain area

Analysing cycling is a popular research trend and has been approached in a number of different ways. A lot of authors stressed the role of cycling in natural environment [Rorthert & Kacprzyk 2012: 65-82; Pisarska & Pisarski 2012: 83-100], however, more often focused on a role of cycling in urban environments [Simonsen & Jorgenson 1996: 5-54; Ritchie 1998: 567-582; Tolley 2003: 3-13]. Some authors posit that cycling was the healthiest way of getting around our cities [Pucher et al. 2010: 7-50]. An especially high number of projects undertaken have focused on towns and cities in Western Europe [Pucher & Buehler 2008: 495-528], including cycling for slower travel [Dickinson et al. 2010]. The economical aspect of such research characterised market conditions influencing the develop-

ment of bicycle tourism [Niezgoda 2012: 29-40] and the marketing aspect analysed motivations of practising cycling [Figler et al. 1992: 113-116; Zawadka 2012: 295-306]. Research on cycling in urban areas and as a mean of urban transportation [Rietveld & Daniel, 2004: 531-550], and sustainable development [Bratzel 1990: 177-190; Bertolini 1999: 199-210; Bertolini & le Clercq 2009: 575-589] are essential for our paper. Although researches analysing bicycle tourism development in towns and cities [Sun Chao et al. 2012: 5-16; Sidong et al. 2012: 5-6] are equally important.

Urban bike trails have a specific character because, according to A. Stasiak, J. Śledzińska and B. Włodarczyk [2014: 11-58], in such areas, combinations of separate bikeways and footways, commonly called routes for pedestrians and cyclists or bike paths, are the most common. Traditional bike trails marked, according to T. Dronka [2012: 141-152], with primary and secondary markings (signposts and information boards) and surrounded by complementary infrastructure (e.g., developed resting points) are more common outside the tightly built-up urban areas because there are more bikers. Bike trails are marked in order to move tourist cycling from high-traffic streets and roads to safe bikeways or side roads of different kinds [Boroński 2007: 171-174]. Official statistics indicate that, nowadays, Poland has 19.5 thousand km of bike trails with the highest amount in the following voivodeships: Zachodniopomorskie, Lubuskie, Małopolskie, and Wielkopolskie as it results from the in Poland [GUS 2015]. The following voivodeships show the highest index of bike trails density: Małopolskie, Lubuskie, Zachodniopomorskie, and Śląskie [Śledzińska 2012: 41-64]. Bikeways, the most common element of touristic development, can be divided according to Stasiak et al. [2014: 11-58] into the following types:

– separate bikeways (usually outside urban areas),

– separate in-roadway bikeways (next to a roadway, often separated from a roadway with a greenbelt),

– separated from a roadway with a low curb or painted line (bike lanes, contraflow bike lanes - enabling cycling in only one direction),

– separated from a sidewalk with a low curb, different surface colour or painted line (road surface markings).

It should be noted that a high selection of bike maps and applications, more accurate and up-to-date than traditional paper maps, is now available due to dynamic changes in digital technology. Such applications enable accesss to the newest maps and a number of other functions such as measuring speed, distance, time, altitude, ride's profile, and burned calories. Their practical application is stressed by A. Kalaniewicz [2012: 133-140; 2016], among others. The following applications can be considered the most interesting ones: iMapMyRIDE, Bike Repair HD, Move! Bike Computer, Strava Cycling, Endomondo Sports Tracker, Cyctastic GPS. This applications have a lot usefull data for bikers. Using bike

maps and applications makes bike trips easier and more pleasant. In addition, it creates a sense of security and allows controlling oneself and one's achievements through analysis and observation of displayed results. With such software, it is possible to obtain any data and calculations interesting for us almost immediately, like average and maximal pulse, speed, elevation and air temperature. It can to make a correlations with they.

Current condition of bike recreation development in the Poznań agglomeration was also analysed in the aspect of conditions of developing bike tourism and infrastructure [Billert 2012: 121-132; Zamelska & Kaczor 2015: 105-121; Styperek 2015: 201-213], motives and preferences of cyclists [Graja-Zwolińska &Spychała 2012: 281-194; Łuczak & Kroma 2015: 123-143; Rogowski & Nadolski 2016: 137-155]. Poznań City Council had noticed the necessity of developing bike infrastructure and, within realisation of transport policy, implemented the Bike Programme for 2007-2015 including, among others, possibility of improving cycling safety and conditions, implementing new forms of public transportation – public bicycles, improving routes of bike trails within the city, tourist and leisure bike trails, and promotion of cycling [*Program rowerowy...* 2008]. The effects of that were already noticed by S. Graja-Zwolińska and A. Spychała [2012: 281-194], who stressed that the authorities of Poznań propagate development of cycling infrastructure through organising new bikeways and next public bike stations. Thus, the role of the Poznań City Bike is increasing.

Interesting papers characterising tourist values and bike maps of the Poznań agglomeration were so far published, for example, eight editions of cycling guides of J.Y. Łuczak published by the Municipal Roads Authority of Poznań in which the author describes numerous cycling trails and trips. The "Poznań na dwóch kółkach" map (2013) and "Rowerowa mapa Poznania" online map are also noteworthy. Both elaborations are the most current and detailed and contain all the information needed by cyclists, such as descriptions of different routes (bikeways, connecting paths, marked bike trails, separated bikeways, routes for pedestrians and cyclists and contraflow bike lanes), obstructions, and facilitations (e.g., the zone 30)[2] and city bike stations.[3]

3. Methodology (measuring technique)

Three factors were taken into consideration when developing the methodology of analysing a system of bike trails: landscape, bike trails, chosen cyclists. These factors are presented in the below diagram (Fig. 1) referring to linear systems of

[2] www.zdm.poznan.pl/strefa30.php [access: 16.03.2017].

[3] https://nextbike.pl/miasta/poznanski-rower-miejski/ [access: 15.03.2017].

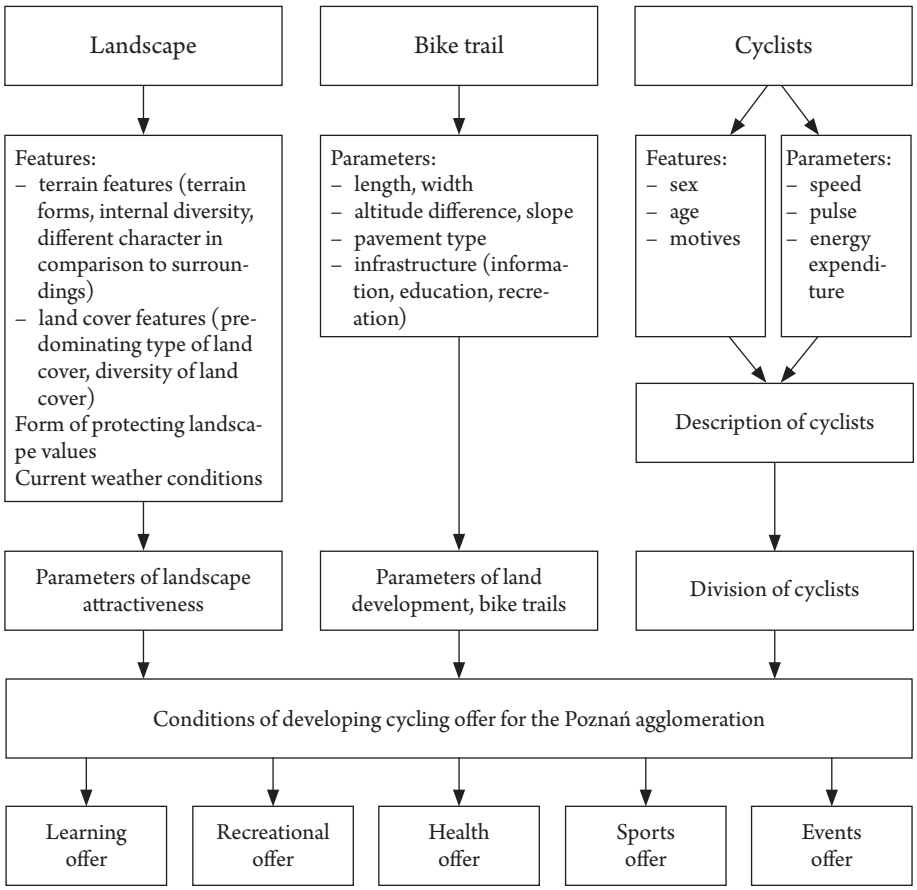


Figure 1. Research procedure

Source: own work.

recreational penetration in the geoecological approach [Styperek 2002: 15-56]. In this approach the system's elements are: participants travelling within tourist space, system's axis that is the penetration route and its infrastructure, and natural and cultural landscape located in the visual perception zone. While the complex of mutual interactions includes interactions between the system's elements as a result of recreational penetration.

The landscape will be analysed with Geographic Information System tools using criteria deciding on the attractiveness (diversity and changeability) of terrain forms and land cover. Garmin Edge 810 Bundle Tp Light cyclocomputer manufactured by Garmin (designed for cyclists) was the main tool for analysing bike trails and cyclists. The device uses satellite navigation in cooperation with

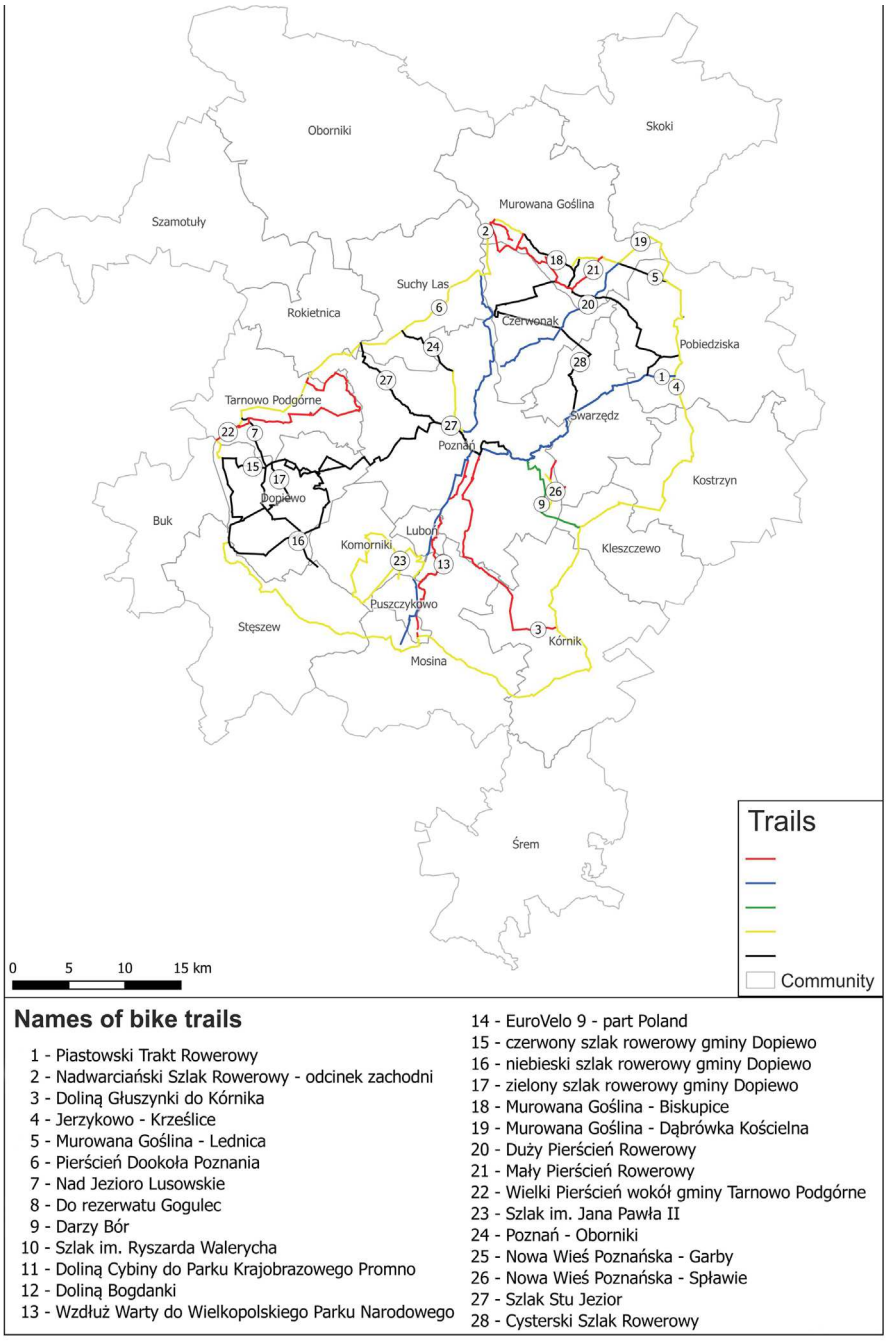
software available on the manufacturer's website (http://connect.garmin.com). This device allows detailed determination of a completed route's length as well as related characteristics, i.e., speed, altitude, and slope. If necessary, it also divides a route into stages. In addition, measurements included such parameters as mean and average and maximal pulse and energy expenditure expressed as burned calories. Individual calibration of the device requires entering data, such as sex, weight, and resting and maximal pulse into device's memory. Data obtained from every ride are presented in tables and graphs, and they are analysed statistically. It is possible to use these data to develop recreational offert for the Poznań agglomeration including different intensity levels. The possibilities of use this software will be presented for one person excemple.

4. Wielkopolska System of Bike Trails

The subject of the research is a part of the Wielkopolska System of Bike Trails located in the Poznań agglomeration. The system was established back in 2001 and now it consists of nine transregional bike trails of the total length of about 1800 km. The system includes historical and cultural trails, such as the Amber Bike Trail and the Polish Landed Gentry Bike Trail. The attractiveness of the Wielkopolska System of Bike Trails can be proved by the fact that it was granted a special Certificate of the Polish Tourist Organisation in 2004. Moreover, this system is a part of the "GPS Wielkopolska" project which established "GPS traits," the so-called tracks that can be downloaded to mobile devices, e.g., mobile phones based on satellite navigation [Kaleniewicz 2012: 133-140].

In this research on the phenomenon of recreation in the Poznań agglomeration, we concentrated on one part of the Wielkopolska System of Bike Trails, that is, the Poznan Bicycle Ring along with seven accesss trails led from the city centre. The Ring of about 170 km is divided into 7 sub-trails by the 7 accesss trails. The Wielkopolska System of Bike Trails consists of the following trails: Poznan Bicycle Ring, Cistercian Bike Trail, Warta Bike Trail, Piast Bike Trail, Bike Trail of a Hundred Lakes, Trans-Wielkopolska Bike Trail (Fig. 2).

For the pilot study was chose one of the bike trails of the Poznan Bicycle Ring. The trail starts in the city centre, in the so-called Poznań Bike Node, located by the Maltańskie Lake at the corner of Baraniaka and Jana Pawła II streets. This trail is marked in green and it is the northern part of the Trans-Wielkopolska Bicycle Trail. The studied trail leads through river valleys of Bogdanka and Cybina where several reservoirs are located: ponds of the Sołacki Park, Rusałka Lake, and Strzeszyńskie Lake. The trail's route lines up with one of belts of the so-called wedge-ring greenery system of the city of Poznań (Fig. 3). High tourist



Names of bike trails

1 - Piastowski Trakt Rowerowy
2 - Nadwarciański Szlak Rowerowy - odcinek zachodni
3 - Doliną Głuszynki do Kórnika
4 - Jerzykowo - Krześlice
5 - Murowana Goślina - Lednica
6 - Pierścień Dookoła Poznania
7 - Nad Jezioro Lusowskie
8 - Do rezerwatu Gogulec
9 - Darzy Bór
10 - Szlak im. Ryszarda Walerycha
11 - Doliną Cybiny do Parku Krajobrazowego Promno
12 - Doliną Bogdanki
13 - Wzdłuż Warty do Wielkopolskiego Parku Narodowego
14 - EuroVelo 9 - part Poland
15 - czerwony szlak rowerowy gminy Dopiewo
16 - niebieski szlak rowerowy gminy Dopiewo
17 - zielony szlak rowerowy gminy Dopiewo
18 - Murowana Goślina - Biskupice
19 - Murowana Goślina - Dąbrówka Kościelna
20 - Duży Pierścień Rowerowy
21 - Mały Pierścień Rowerowy
22 - Wielki Pierścień wokół gminy Tarnowo Podgórne
23 - Szlak im. Jana Pawła II
24 - Poznań - Oborniki
25 - Nowa Wieś Poznańska - Garby
26 - Nowa Wieś Poznańska - Spławie
27 - Szlak Stu Jezior
28 - Cysterski Szlak Rowerowy

Figure 2. The Wielkopolska System of Bike Trails within the Poznań agglomeration

Source: own work.

values (anthropogenic and natural) are characteristic for this section of the trail. Anthropogenic values are sports infrastructure by the Maltańskie Lake, historical architecture around the Old Market Square, Poznań Army Monument, and sports facilities of the Olimpia sports club. Natural values of the trail are the two parks located in the river valley of Bogdanka (Wodziczko Park and Sołacki Park), ecological site "Bogdanka I," Rusałka Lake and Strzeszyńskie Lake, and green areas between them (Fig. 4). Infrastructure of the trail's route and facilities located in its close proximity deserves especial attention. The trail's infrastructure includes: resting sites, information boards concerning various subjects, properly hardened pavement, and self-service bike service stations with four stands containing sets of wrenches and spanners, inflators and universal adapters as well as a code scanning of which displays help. Attractiveness of the analysed trail can also be proved by tourist development of adjacent areas, e.g., several restaurants, beaches and swimming spots be the above-mentioned lakes, volleyball courts, and modern playgrounds.

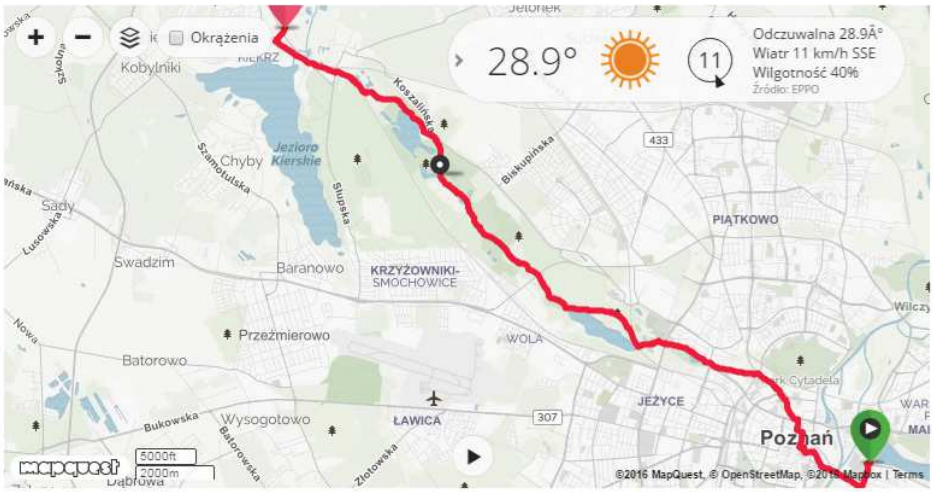


Figure 3. Trait of the exemplary trail

Source: own work based on Garmin Connect; background – the Open Street Map.

The main features determining trail's attractiveness are landscape values connected to post-glacial lakes and high diversification of the surrounding terrain cover. Terrain values include fluvial and glacial terrain forms characteristic for diverse lake districts. Moreover, good level of development in a form of diversifies technological infrastructure and adjusted pavement improves such attractiveness. Land development comprises of route markings, developed resting sites

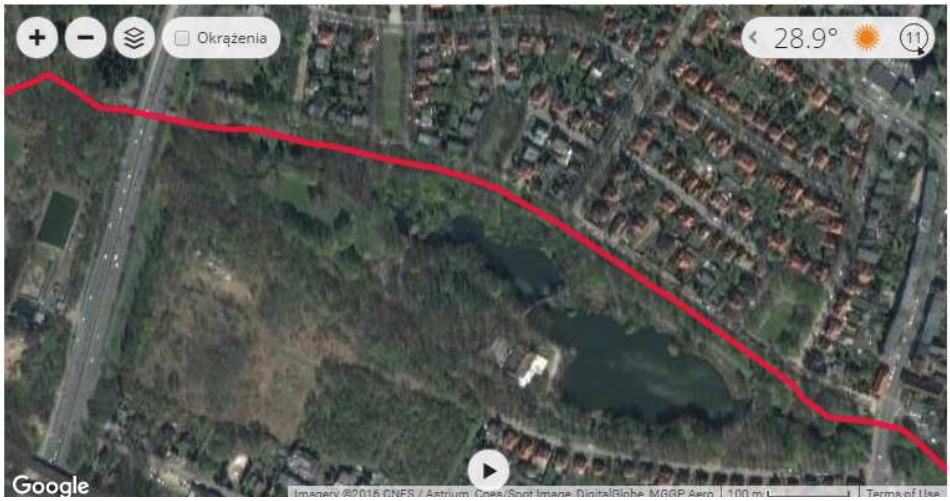


Figure 4. Route of a part of the exemplary bike trail on a satellite image

Source: own work based on Garmin Connect; background Google Maps.

(benches, tables) and educational boards displaying maps. The above-mentioned features determine tourist attractiveness of the analysed trails and influence multisensory landscape perception. This means that analysing parameters of penetration route and physical activity on the trail can comprise premises for optimisation of bike trails' utilisation in the Poznań agglomeration from the point of view of bicycle-using participants.

5. Bike trail's parameters of satellite measurements conducted with the Garmin Edge 810 device

Data obtained during measurements were statistics for one excemple of biker presented as tables, graphs, and maps. The analysed trail had 16 km and consisted of flat or slightly sloping sections. According to barometric altimeter used in the measuring device the lowest point measured 59 m a.s.l., and the highest – 94 m a.s.l., what means that trail's denivelation amounted to 35 m (Chart 1). Low denivelation and low values of increase (82 m) and decrease (65 m) proved very low level of difficulty concerning terrain configuration along the entire trail. Analysis of heights of individual sections of the length of 1 km clearly showed that the average value of altitude increase and decrease amounted to about 4-5m. The highest

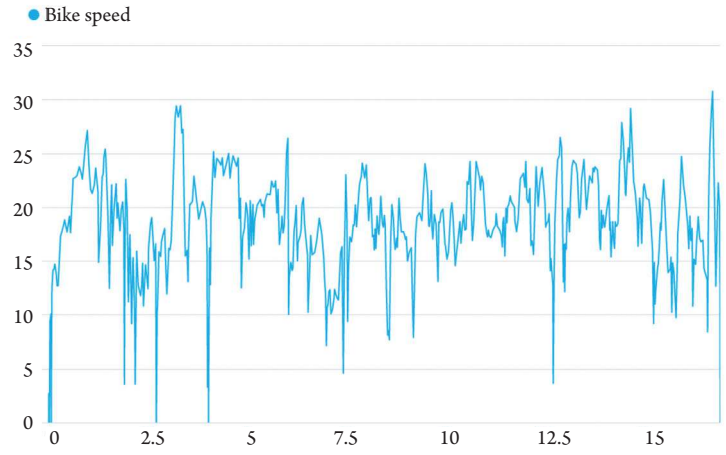
Chart 1. Altitude profile of the exemplary bike trail

Source: own work based on Garmin Connect.

value of the increase was 12 m, and in the one section altitude increase did not occur at all. The highest value of altitude decrease was 11 m while in four sections decrease was not registered.

The next data was the current speed during the whole ride. As it results from the registered data, the average speed of the ride was 16.4 km/h, however, it in-

Chart 2. Speed profile of a ride on the exemplary bike trail

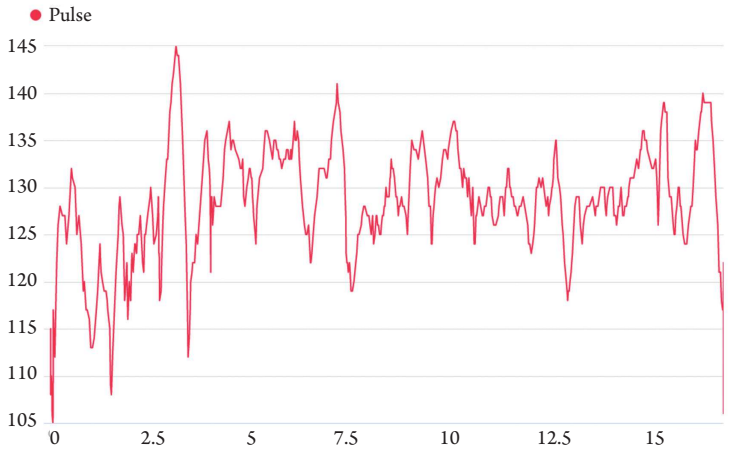


Source: own work based on Garmin Connect.

cluded the time of stopping. While the average movement speed was 18.8 km/h with the maximal speed of 31 km/h (Chart 2).

The measurements also included parameters of physical activity, such as pulse and energy expenditure. Characterisation of pulse included average and maximal values. The average values of pulse in individual sections were slightly diverse and ranged from 119 to 132, while maximal values of pulse ranged from 129 to 145, respectively (Chart 3). The energy expenditure was expressed as burned calories. It is an especially important feature because information on burned calories can significantly contribute to undertaking recreational activity for health. The person participating in the research burned 484 kcal during the entire route, while the energy expenditure in individual sections of the trail ranged from 19 kcal to 49 kcal. Additional measured parameters helpful in analysing physical activity included: time of the ride, average and maximal movement speed, and air temperature in individual sections of the trail.

Chart 3. Cyclist's pulse during riding the exemplary bike trail

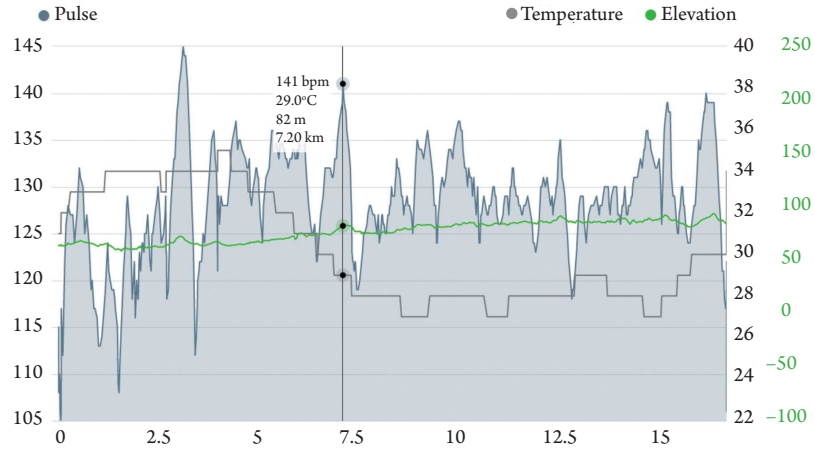


Source: own work based on Garmin Connect.

The used software enabled multilayer analysis of measured parameters in graphs, e.g., pulse changes (pulse) or speed changed depending on changes in terrain configuration, etc. This option enables easier interpretation of recreational activity's results. It is also possible to analyse the above features at individual points of the trail thanks to synchronisation of the map with the statistical data. Below interactions between the obtained data are presented:

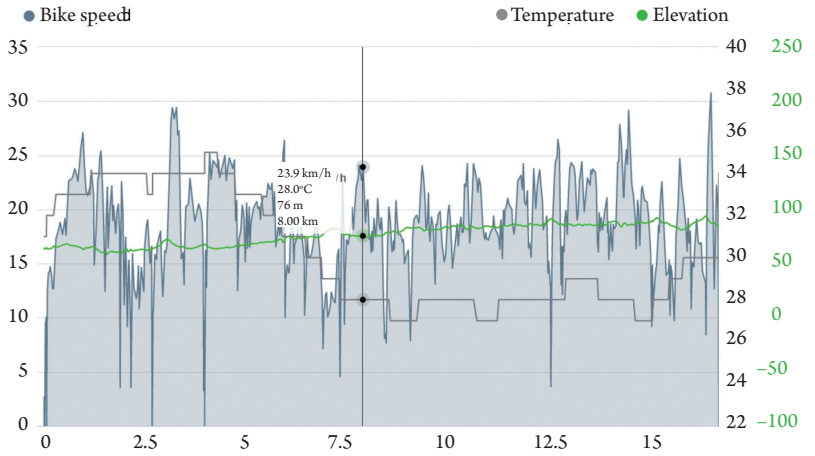
- pulse, air temperature, and altitude a.s.l. (Chart 4),
- speed, air temperature, and altitude a.s.l. (Chart 5),
- speed, pulse, and altitude a.s.l. (Chart 6).

Chart 4. Interaction between pulse, air temperature, and altitude a.s.l.



Source: own work based on Garmin Connect.

Chart 5. Interaction between speed, air temperature, and altitude a.s.l.



Source: own work based on Garmin Connect.

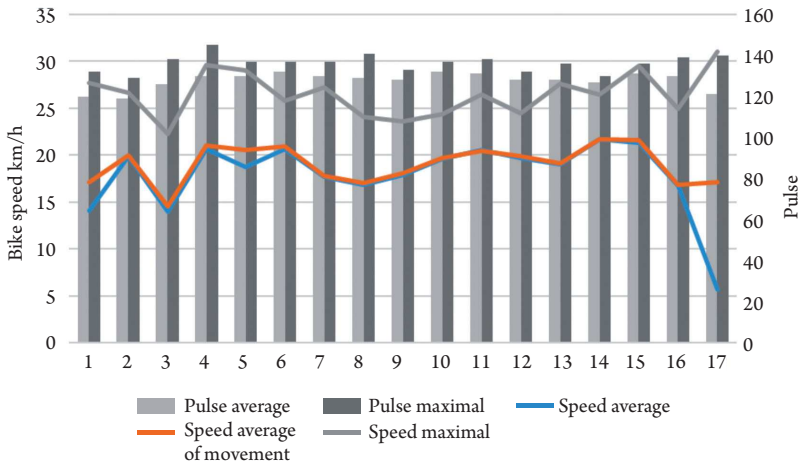
The exemplary trail was divided into 1-km sections in which a number of data were measured: time, movement time, altitude increase, altitude decrease, average speed, average movement speed, Mmax. speed, average pulse, max. pulse, average air temperature, and calories (Table 1).

Chart 6. Interaction between speed, pulse, and altitude a.s.l.

Source: own work based on Garmin Connect.

The above specification can be the base for further analysis which would include a number of features. On use every features. Chart 7 below is an example of such analysis presenting the average and maximal pulse and the average movement speed in 1-km sections of the exemplary bike trail.

Chart 7. Comparison of speed and pulse data in 1-km sections of the exemplary trail



Source: own work.

Table 1. Featured registered with the Garmin Edge 810 Bundle Tp Light device

Section	Time	Movement time	Altitude increase	Altitude decrease	Average speed	Average movement speed	Max. speed	Average pulse	Max. pulse	Average air tempera-ture	Calories*
1	04:16.51	03:30	5	4	14.06	17.14	27.66	120	132	32.30	35
2	03:00.791	03:00	4	6	19.91	20.00	26.68	119	129	33.86	24
3	04:16.951	04:08	9	0	14.01	14.52	22.23	126	138	33.81	38
4	02:54.479	02:51	4	9	20.63	21.05	29.58	130	145	34.00	27
5	03:12.184	02:55	2	2	18.73	20.57	29.03	130	137	34.10	30
6	02:54.112	02:52	4	1	20.67	20.93	25.79	132	137	32.41	28
7	03:23.414	03:22	9	2	17.70	17.82	27.22	130	137	30.51	30
8	03:33.781	03:32	4	7	16.84	16.98	24.08	129	141	28.46	30
9	03:21.91	03:19	5	0	17.90	18.09	23.61	128	133	27.66	27
10	03:04.67	03:03	2	2	19.56	19.67	24.41	132	137	27.61	27
11	02:55.331	02:56	4	4	20.53	20.45	26.43	131	138	27.83	24
12	03:02.938	03:01	2	0	19.68	19.89	24.43	128	132	27.61	23
13	03:08.957	03:08	6	4	19.05	19.15	27.64	128	136	28.00	23
14	02:46.79	02:46	0	0	21.68	21.69	26.46	127	130	28.80	19
15	02:48.957	02:47	6	4	21.31	21.56	29.51	131	136	27.78	22
16	03:35.62	03:34	4	11	16.74	16.82	24.92	130	139	28.13	28
17	09:49.405	03:14	12	9	5.64	17.15	31.02	121	140	31.76	49
Total	01:02:03.65	53:58.00	82	65	16.36	18.82	31.02	127	145	30.52	484

* Middle-aged man, weight about 85 kg.

Source: own work.

6. Conclusions

Concluding the pre-developed methods and exemplary results requires stressing the fact that the presented attempt does not include all the possibilities of analysing the obtained results. It needs to be indicated, however, that further analyses based on all of the bike trails will include all of the compared data. The literature review concerning bike trails of the Poznań agglomeration allows to conclude that bike tourism in the Poznań agglomeration is a subject of many current scientific papers concerning different issues. However, papers describing conditions connected to developing bike tourism and infrastructure as well as conditions of bike physical activity predominate. Some papers also present analyses concerning current state of bike trails and paths in the Poznań agglomeration. Relatively small amount of research concerns detailed characterisation of bike trails' parameters describing their attractiveness and recreational usefulness. Moreover, detailed research determining the size and predominating directions of cycling are lacking. The proposed analysis of trail's parameters and literature review allows formulation of the following prospects for research:

– measuring parameters of the entire system of bike trails in the Poznań agglomeration using the Garmin software,

– classifying the entire system and individual trails according to route's parameters and tourist development, activity (difficulty degree, energy expenditure), popularity, and possibility of creating an offer for an exemplary segment of receivers,

– monitoring cycling on individual trails,

– developing a map of system's attractiveness and popularity of individual bike trails in the Poznań agglomeration,

– preparing multifaceted tourist offer of bike trails in the Poznań agglomeration.

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System szlaków rowerowych aglomeracji poznańskiej – perspektywy badawcze w zakresie aktywności ruchowej i atrakcyjności rekreacyjnej

Streszczenie. Wzrost popularności aktywności rowerowej w Polsce daje podstawę do tworzenia nowych perspektyw badawczych na polu interdyscyplinarnym. Dzięki temu możliwa będzie wieloaspektowa analiza aktywności rekreacyjnej w oparciu o system szlaków rowerowych. Jednym z takich sprawnie działających i zarządzanych systemów jest Wielkopolski System Szlaków Rowerowych (WSSR), który w obszarze aglomeracji poznańskiej jest szczególnie popularny. Celem pracy jest prezentacja wstępnie przygotowanej metodyki analizy systemu szlaków rowerowych w zakresie aktywności ruchowej i atrakcyjności rekreacyjnej wraz z przedstawieniem wstępnych wyników dla przykładowego szlaku. Dzięki uzyskanym danym w dalszym etapie możliwe będzie doprecyzowanie metodyki, dzięki której analizie poddany zostanie krajobraz, szlaki oraz rowerzyści w celu stworzenia ukierunkowanej oferty rekreacyjno-turystycznej w oparciu o Wielkopolski System Szlaków Rowerowych na obszarze aglomeracji poznańskiej.

Słowa kluczowe: turystyka rowerowa, trasy rowerowe, aglomeracja Poznań