The Role of Residence Location in the Spatio-Temporal Walking Patterns of Adolescents: A Case Study in the Post-Socialist Town of Banská Bystrica (Central Slovakia)

Katarína Rišová[1]
Institute of Geography of the Slovak Academy of Sciences, Bratislava

The Role of Residence Location in the Spatio-Temporal Walking Patterns of Adolescents: A Case Study in the Post-Socialist Town of Banská Bystrica (Central Slovakia). Most walking-related research focuses on the spatial behaviour of the adults living in the studied areas and omits other pedestrians. The aim of this study was to uncover possible differences in the spatio-temporal patterns of adolescents' walking activities, according to the location of their residence. The research was carried out in an electoral ward in the post-socialist town of Banská Bystrica (Central Slovakia). A total of 295 participants aged 13 to 16 years (103 of whom were residents of the ward) recorded their walking activity at hourly intervals. The residents of the ward were only more active than other pedestrians during a few afternoon and evening periods, with differences up to 13:00 not being significant at all. The lowest dispersion of walking activity space was recorded for participants residing other municipalities. The lesser walking activity by non-residents is in line with current knowledge of the spatio-temporal constraints of commuting individuals, and the time-budget theory.
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***Key words**: Walking patterns; adolescents; residential location; spatio-temporal constraints; Slovakia*

Introduction

Walking is considered the most sustainable mode of transport, from social, economic, and environmental points of view (Rafiemanzelat et al. 2017). As pointed out in a review by Costa et al. (2020), however, children[2] are generally walking less than in the past. Adolescents in post-socialist countries have grown up in a period of a massive automobilisation. Moreover, Pojani et al. (2018) found that cars are still perceived as a status symbol among adolescents in post-socialist societies. This is especially important, as future generations growing up under the same conditions will make similar choices for modes of travel (the generation effect). The behaviour of adolescents can therefore be a predictor of long-term trends in sustainable mobility (Grimal 2020). Rainham et al. (2012) found that active commuting plays an important role in the moderate to vigorous physical activity (PA) of both urban and suburban adolescents. It is also important to focus on youth, as their health behaviour is

[1] Address: Mgr. Katarína Rišová, PhD., Institute of Geography of the Slovak Academy of Sciences, Štefánikova 49, 814 73 Bratislava, Slovakia. E-mail: geogriso@savba.sk

[2] In the walking-related literature, the age categories of children and adolescents are not usually clearly distinguished, and the groups are often examined jointly.

predictive of the behaviour of adults (Rainham et al. 2012), and the generation effect can be seen as a predictor of a long-term trends in sustainable transport (Grimal 2020).

Stafford and Baldwin (2018), however, note that most walking-related studies have considered the needs of a uniform individual, or the so-called "average adult". Walking behaviour research and walking environment assessment have overlooked the diversity of age categories, as well as the physically and mentally determined abilities of individuals. What is more, as shown in a review by Rišová (2020), this research gap is much more serious in the post-socialist countries, with an absence of studies dealing with various lifestyles (e.g., retirees, parents on maternity leave, pupils, and students). A healthy working adult, who is also a resident of the study area, is often considered the only relevant subject, but this does not reflect reality because this model pedestrian is not the only public space user.

All the forgotten, silent, and undesirable people in public spaces can be considered marginal (Kurniawati 2012). According to Badshah (1996), children are marginalised in public space and belong to "the silent" group. This study is a reaction to the fact that this label is also applicable to adolescents, since their opinions on the quality of public space are often neglected, although they use public spaces for walking as much as adults. The impossibility of holding a driving license in Slovakia before the age of 17 also means that pedestrian routes are more intensively used by adolescents. Participation in decision-making processes, such as municipal elections or voting for the redistribution of money within a participatory town budget, is also limited according to age. The non-residents of an area are also a marginalised group as regards opportunities to participate in decision-making processes, and should be given scientific attention accordingly. It is necessary to study the walking behaviour of all the overlooked groups of individuals, to ensure that the needs of all public space users will be met.

In response to this issue, the aim of the study was to examine the intensity of walking, as well the walking patterns of 13-16 year old adolescents, with a special emphasis on revealing possible differences between individuals who live in different residence locations (in a particular town ward, or in another municipality). This study is place-oriented, in the sense that it examines the space in which individuals move, without considering other activities that the same individuals undertake outside this area.

Theoretical background

The concept of walking has not been understood uniformly in the scientific literature. Some authors have focused exclusively on walking for transport (e.g.

Cerin et al. 2007; Hatamzadeh – Hosseinzadeh, 2020; Koohsari et al. 2019), in other studies, only walking for recreation was considered (e.g. Aliyas 2019; Cerin et al. 2013). This distinction has not been applied in other studies (e.g. Nordh et al. 2017; Owen et al. 2007; Yang – Diez-Roux 2012). Another common approach has been to examine active transport in general, which refers to both walking and cycling (e.g. Ghekiere et al. 2016; Jones et al. 2019).

A modified version of the activity space (AS) concept was used in this study. AS can be defined as an area within which individuals move during a certain time period, while performing their activities (Ren 2016). Scholars often do not consider travel modes when examining an AS. As this study is walking-focused, the term walking activity space (WAS) is used, and refers to the part of an AS, which was reached only by foot.

Walking patterns are determined not only according to environmental variables, but also to the characteristics of pedestrians. Important differences are related to, for example, gender[3], age, physical abilities, lifestyle and the life stage of individuals. Groups defined by these characteristics walk through the urban area at different times and for different purposes, and their routes have different spatial patterns.

The reasons for these different patterns are often rooted in the different time budgets of individuals or different time schedules resulting from the nature of their fixed activities. Other people's time schedules also play an important role for some pedestrians. An example is the afternoon nap of young children, which acts as a barrier to parents or caregivers moving around the city. The spatio-temporal patterns of pupils and students who live in different town wards or municipalities to their schools are often tied to public transport timetables or to an adult who can drive them by car (Pospíšilová – Ouředníček 2011). As revealed in a review by Villanueva et al. (2012), the activity space of children is affected by the age of a child, their friends and/or siblings, dependence on traveling with an adult, a child's orientation skills, parental perceptions of neighbourhood safety, parental restrictions, and traffic safety.

Having chosen adolescents as study participants, it can be assumed that the distribution, area and shape of the WAS will be affected mainly by the locations of school and home, as, according to other authors, these are the most commonly visited destinations when walking (e.g. Chambers et al. 2017; Millward et al. 2013). According to the spatio-temporal approach used in this study, most home and school-located activities are considered fixed, which means that their relocation to another place and time is difficult or impossible (e.g. Miller 2005, 2017).

[3] Gender has been considered by Rišová and Sládeková Madajová (2020), and Rišová (2021) when examining perceptions of the walking environment and walking patterns of adolescents in Banská Bystrica.

Specifics of the walking environment in post-socialist cities

Urban planning in the socialist period of Central and Eastern European countries had both positive and negative effects on public space. Urban development was then fully under government control and without commercial investment. Urban land was not for sale, and therefore did not have commercial value. It was therefore possible to build infrastructure with no financial profit, such as parks and playgrounds, even in the most potentially lucrative locations (Kotus 2006). The newly-built parks and squares were also particularly generously sized (Hirt 2014).

The situation for urban facilities was more complicated, however. Although Soviet planners prepared detailed plans of urban facilities in newly-built neighbourhoods, which was called the microrayon concept (for a more detailed description see, e.g. Marozas 2016), the plans were only partially realised. Some of the facilities (e.g. trade and public catering enterprises) turned out to be considered secondary, and their construction was postponed indefinitely. Nikšič (2017) is more optimistic and sees socialist cities as relatively successful in terms of both their walkability and urban justice, because facilities for daily needs (e.g. primary education and shopping) are located within walking distance of homes. It should be pointed out, however, that facilities were often reduced to a very basic level.

At the beginning of the 1990s, post-socialist towns and cities began to undergo significant changes. The transition has been described by numerous authors (e.g. Malý et al. 2020; Stanilov 2007; Sýkora 1999; Sýkora – Bouzarovski 2012). The most important processes transforming post-socialist public space are the erosion of public ownership and related massive privatisation and commercialisation (Barnfield – Plyushteva 2016; Hirt 2014). New shops, services and start-ups began to emerge, although the pre-socialist quarters with smaller parcels of land and buildings were able to adapt to the new conditions more easily than the areas built in the socialist period (Stanilov 2007). The distribution of urban facilities in post-socialist cities is therefore different to that in other parts of the world. Facilities are often increasingly concentrated in historic city centres, which are more suitable for commercialisation due to their specific morphology.

Suburbanisation and the related increased car-ownership also gradually became important trends in post-socialist countries, and led to changes in people's choice of travel modes. The increased distances between home and other destinations, together with the new economic conditions, created a trend of massive automobilisation across society. Walking was replaced by faster travel modes, even for children's daily journeys to school (Burgmanis 2012).

During the socialist period, public transport played a major role in the work and school commute, but during the 1990s, the number of public transport users dropped sharply (Stanilov 2007). Nevertheless, public transport still plays an important role in the post-socialist space.

As pointed out by Radzimski and Gadziński (2019), although suburbanisation is not a privilege of post-socialist countries, it occurred there within a relatively short period. Kotus (2006) compared such processes with the Fordist era in the US, albeit with a time lag and on a smaller scale in the case of the Eastern and Central Europe.

Some characteristics of individual travel behaviour are particularly typical of post-socialist society. To understand them, it is necessary to look at the context of the former political regime and the personal experiences of the inhabitants. Firstly, after the revolution years, cars became not only symbols of social status, but also of a hard-gained freedom (Burgmanis 2012). Secondly, any effort to create regulations and government control is now perceived as an assault on personal rights or an attempt to reinstate old socialist practises (Suchorzewski 1999; Sýkora 1999). Finally, in a society in which people's individuality has been suppressed for years, it is now difficult to convince citizens of the importance of collective benefit. In this regard, Marozas (2016: 65) mentioned "the rise of individualism and weakening sense of community", as well as the "manifestation of the freedoms that did not exist before".

Although today's adolescents did not experience the former socialist political regime, they have grown up in a society which is still strongly influenced by its past. As shown in another post-socialist country, Latvia, family driving habits are one of the most influential variables in the choice of travel mode when commuting to school, in the case of 12-17-year-old children (Burgmanis 2012).

Residential location and the walking behaviour of individuals

There has already been a focus on examining differences in the PA of adolescents according to urbanicity (the degree to which an area is urban). Adolescent-focused studies have typically differentiated an urban-rural dichotomy (Booth et al. 2004; Liu et al. 2008; Plotnikoff et al. 2004; Sjolie et al. 2002) and an urban-rural-suburban triad (Felton et al. 2002; Springer et al. 2006; Springer et al. 2009).

Lu et al. (2017) reviewed Chinese papers dealing with PA, showing that while urban children took part in more PA than those from rural and suburban areas, the results for adolescents were inconclusive. In contrast, Rainham et al. (2012) found urban adolescents to be more active, and also that PA declined with the older age of the adolescent. Even though walking is defined as moderate to vigorous or non-organised PA in such studies, activity is only

assessed in general, without distinguishing active transport (exceptions are, e.g., Rainham et al. 2012; Sjolie et al. 2002). There has also not been an assessment of how much PA takes place in urban centres, nor whether or to what extent adolescents living in suburban and rural environments concentrate their PA in cities.

Studies examining active transport showed that both urban adolescents and adults tend to walk to a greater extent compared to those from rural and suburban areas (Morris et al. 2019; Rainham et al. 2012; Sjolie et al. 2002). As revealed by Nelson et al. (2006), however, the results are not the same for all types of suburbs, with youths from older suburban areas being more active than those from new suburbs. This tends to be because suburban and rural areas are less walkable than cities, due to their generally lower residential density, less connected street networks, and less diverse land use, as first demonstrated by Cervero and Kockelman (1997). While the students in the studies above often attended schools near their place of their residence, however, the partici-pants in our research all attended schools in the same town centre and its immediate surroundings. This reflects a typical situation in Slovakia, where suburban and rural areas do not include high schools, and often not even primary schools, so that most adolescents have to travel to urban areas each day.

It was therefore more beneficial in this case study to consider the spatio-temporal constraints related to a time-budget theory. The more time individuals spend in transport, the less time remains for other activities (Pospíšilová – Ouředníček 2011; Putnam 2001) including leisure and walking for recreation. Although there are studies showing that residents of suburbs spend a similar amount of time commuting, evidence suggests that this is mostly by car, and less via public transport, cycling, or walking (e.g., Morris – Pfeiffer 2016).

This study is also based on the assumption of similarity in the behaviour of individuals with common residential locations. This is related to the spatial dependence concept, which originated in Tobler's first law of geography: *"Everything is related to everything else, but near things are more related than distant things"* (Tobler 1970: 236). In this paper, "close things" are considered to be the residents of the ward under study. According to Tobler's law, our assumption is that the spatial behaviour of residents demonstrates common spatial patterns, while the walking patterns of other public space users are different. In this context, spatial dependence is expected among individuals living in the same neighbourhood, since they are affected by similar spatial conditions (Chica-Olmo et al. 2018), such as crime rates or transport accessibility. Tobler's law, however, has so far been mentioned in a limited

number of transport geography works only (e.g., Chica-Olmo et al. 2018; Clark – Rey 2017; Miller 1999).

Research to date has shown that individuals mainly visit those places that are more familiar to them, and that their activities tended to be minimalised in areas less familiar to them (Namin et al. 2013; Rahman et al. 2015). The frequency of use of a public space and familiarity with it are also related to safety perceptions (McCray – Mora 2011; Rahman et al. 2015; Traunmueller et al. 2016). According to research by Abbott-Chapman and Robertson (2009), familiar areas are important for adolescents, who consider them their favourite places in the city, and prefer them for their individual or collective activities. The frequency of public space use (Rahman et al. 2015), as well as the extent of PA there (da Silva et al. 2017; Dias et al. 2018 and 2019; Zook et al. 2014), is also related to proximity, which favours residents.

Based on the above, it can be expected that residents of the ward under study will walk through its area to a greater extent than non-residents. Since other research dealing with residence location in relation to walking activity does not consider spatio-temporal variations, however, there is a need for further examination. The research presented here is also different in that all participants attend school in the same ward of the town, regardless of where their home is located, and also due to its place-oriented approach. We present the research questions as follows:

1. Are there any significant differences in walking intensity between adolescents residing in a research area and their peers living elsewhere? If so, do the differences vary according to the time of day?
2. Are there any differences in the spatio-temporal patterns of adolescents' WASs according to residential location?

In order to answer these questions, data collected during a mapping activity was analysed. This technique has proved to be an efficient tool for examining the activities of children and adolescents in public spaces (McCray – Mora 2011; Rišová 2021; Villanueva et al. 2012) as well as their safety perceptions (Rišová – Sládeková Madajová 2020).

Methods

The research was carried out in the oldest ward of Banská Bystrica town (central Slovakia), which is unusual for its heterogeneous functional and morphological structure, as well as for its medieval historical core, with numerous adjacent alleys and neighbourhoods built in both the socialist and post-socialist periods. All the primary and secondary schools located in the study ward were invited to join the research. Only the results relating to

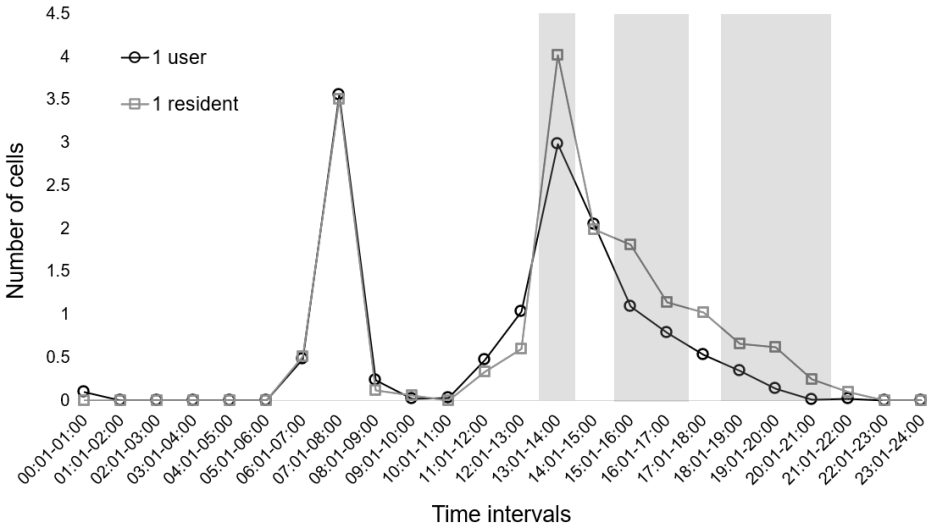
participants who stated whether they lived in the ward are presented, to enable an accurate comparison. The final sample consisted of 295 participants (of which 54.92 % were girls) aged 13-16 years, attending one of three primary and three secondary schools. Of this number, 103 were residents of the ward and 192 were defined as other users of public space (hereinafter referred to as "users"). For the purposes of standard deviational ellipse (SDE) analysis (explained below), the users were further differentiated as residents of the town of Banská Bystrica (Users A) and residents of other municipalities (Users B). While the residents and Users A can be considered urban dwellers, the exact residential location of Users B was not traced during the data collection. However, the vicinity of Banská Bystrica is typically rural, with occasional elements of suburbanisation. It can therefore be assumed that Users B are mostly inhabitants of such settlements. The research was conducted during a short period from November to December 2018, to ensure similar lighting conditions throughout the whole data collection. During the activity, students worked with a map of the ward divided by a square grid into cells measuring 200 x 200 metres, and were asked to fill in a form with a time–space diary included. The cells they had walked through the previous day at hourly time intervals were marked in the diary. A more detailed description of the activity and the materials used has been published elsewhere (Rišová – Sládeková Madajová 2020; Rišová 2021).

Walking intensity was expressed as the number of cells passed through by an average resident or an average user during a particular time interval. Based on the results of a Shapiro-Wilk normality test and Levene's test of homogeneity of variances, a Mann Whitney U test was implemented to identify significant differences between the two participant groups examined. The significance level was set at 0.05. Differences were monitored not only during hourly time intervals, but also separately for daylight (7:01-16:00), after dark (16:01-7:00), and generally for the whole 24 hours. Standard deviational ellipse (SDE) analysis was performed to calculate the spatial attributes of WAS. This made it possible to display the aggregated WAS (for every residence category), as well as its spatial attributes – dispersion rate, shape, location of a centroid, and rotation. The percentage of residents and users walking through a particular cell in a selected time interval was chosen as a weight for calculations.

Results

It was possible to record the morning and afternoon pedestrian traffic peaks (Figure 1) occurring during the intervals of 7:01-8:00 and 13:01-14:00. The most intensive walking was recorded during these hours. As shown in Table 1, significant differences were found only during the afternoon hours of 13:01-

Figure 1: **Number of cells walked through by an average resident and other public space users during the day.** (Significant values are indicated using blocks)



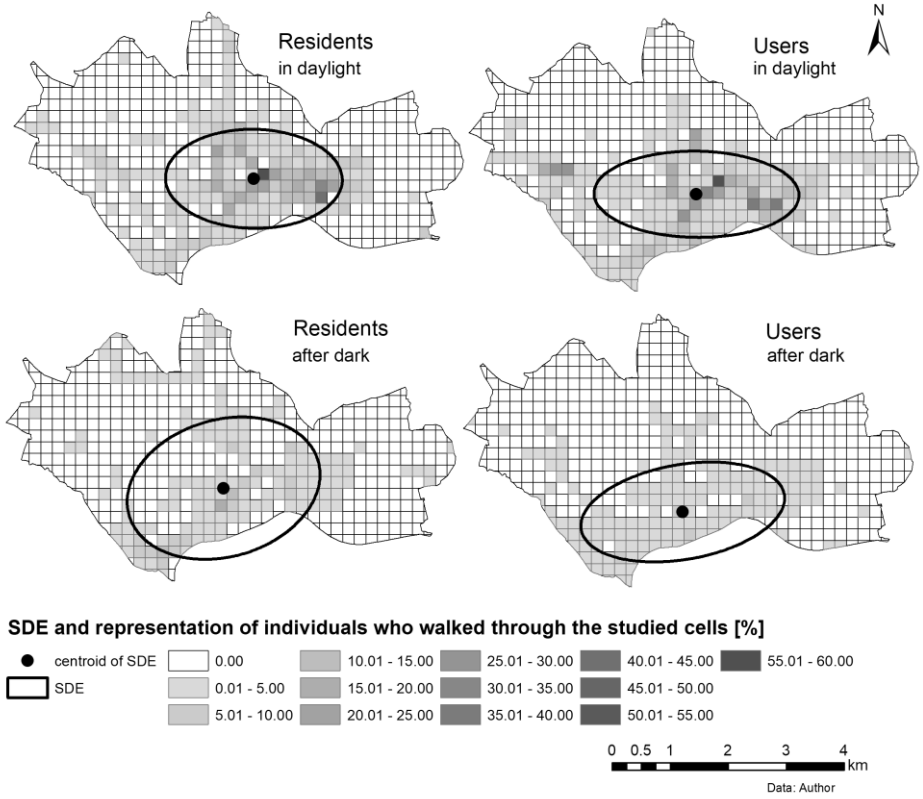
14:00, 15:01-17:00, and 18:01-20:01, as well as after dark in general, and in all the cases mentioned, walking was more intense for residents. On the other hand, adolescents did not use the walking routes at all at night. No significant differences were found when looking at walking for the whole 24 hours, in daylight in general, and between 06:01-13:00. The spatial distribution of the cells in which the participants walked is shown in Figure 2. The attributes of SDE, namely, the length of axes, rotation, and area of SDE, are shown in Table 2. Although the location of both centroids in the north-western part of the historical core may seem similar, slight differences can still be observed here. While the centroid of users was shifted towards the pedestrian zone as a potential area of interest for their activities, the centroid of residents was located closer to the east, with a larger concentration of housing units. Another interesting finding pertains to the fact that during the day, there was an evident

Table 1: **Differences in walking intensity according to residential location**

	Number of cells		Prevailing	Mann-Whitney U	*p*-value
	Average resident	Average user			
In daylight	12.4369	11.4600	residents	10002.0000	0.8713
After dark	4.3010	2.4100	residents	11986.0000	0.0007
24 hours	16.7379	13.8800	residents	11183.0000	0.0635
00:01-01:00	0.0000	0.0990	users	9733.5000	0.2045
01:01-02:00	0.0000	0.0000	NA	9888.0000	NA
02:01-03:00	0.0000	0.0000	NA	9888.0000	NA
03:01-04:00	0.0000	0.0000	NA	9888.0000	NA
04:01-05:00	0.0000	0.0000	NA	9888.0000	NA
05:01-06:00	0.0000	0.0000	NA	9888.0000	NA
06:01-07:00	0.5146	0.4844	residents	9773.5000	0.7838
07:01-08:00	3.5049	3.5521	users	10080.0000	0.7813
08:01-09:00	0.1165	0.2344	users	9698.0000	0.4760
09:01-10:00	0.0583	0.0156	residents	10028.0000	0.2487
10:01-11:00	0.0000	0.0260	users	9785.0000	0.3018
11:01-12:00	0.3301	0.4740	users	9635.5000	0.4282
12:01-13:00	0.6019	1.0313	users	9182.0000	0.1064
13:01-14:00	4.0194	2.9844	residents	11855.0000	0.0040
14:01-15:00	1.9903	2.0521	users	9588.5000	0.6277
15:01-16:00	1.8155	1.0938	residents	11066.0000	0.0356
16:01-17:00	1.1456	0.7865	residents	10820.0000	0.0428
17:01-18:00	1.0194	0.5313	residents	10641.0000	0.0791
18:01-19:00	0.6602	0.3438	residents	10783.0000	0.0161
19:01-20:00	0.6214	0.1406	residents	10844.0000	0.0046
20:01-21:00	0.2427	0.0104	residents	10510.0000	0.0016
21:01-22:00	0.0971	0.0156	residents	9977.5000	0.5247
22:01-23:00	0.0000	0.0000	NA	9888.0000	NA
23:01-24:00	0.0000	0.0000	NA	9888.0000	NA

movement of the participants' ellipses to the south. This movement suggests that while most of the participants used only the northern part of the ward in the morning, this trend changed during the day. The shift in the ellipses of both groups, as well as their marked rotation after dark (residents = 73.97°, users = 80.16°), were largely affected by the location of the largest shopping centre (Figure 3). Cell No. 15, in which the eastern entrance to the shopping centre is located, was the most frequently visited cell by users, and the third most frequently visited cell by residents after dark (Table 4).

Figure 2: **Spatial distribution of WAS according to residential location**



Another factor affecting SDE movement and rotation after dark was walking through cell no. 110 (SNP Square, pedestrian zone), which was the most frequently visited cell for residents, and the third most frequented for users. There was also increased walking in an area with a predominance of traffic after dark. In daylight, including both rush hours, the southern part of the users' ellipse was located at the public transport hubs, including the main bus

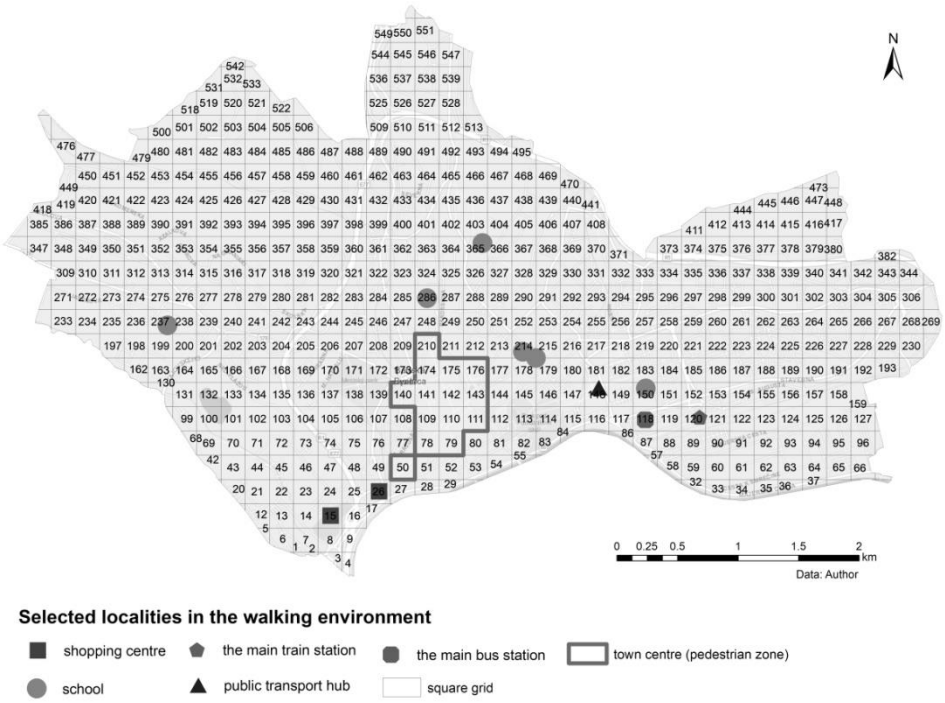
Table 2: **Quantitative attributes of SDE according to residential location.**

	Group of participants	Length of axes		Rotation [°]	Dispersion
		X	Y		
In daylight	Residents	1.52	0.85	90.95	4.09
	Users	1.77	0.74	90.71	4.13
	Users A	1.86	0.86	92.29	5.05
	Users B	1.71	0.66	89.76	3.55
After dark	Residents	1.70	1.18	73.97	6.29
	Users	1.78	0.82	80.16	4.57
	Users A	1.60	0.83	79.30	4.15
	Users B	1.94	0.80	81.01	4.89
7:01-8:00	Residents	1.46	0.78	97.83	3.59
	Users	1.86	0.72	92.77	4.21
	Users A	2.01	0.79	94.69	4.98
	Users B	1.75	0.63	91.85	3.44
13:01-14:00	Residents	1.36	0.82	95.90	3.49
	Users	1.54	0.62	87.73	3.00
	Users A	1.60	0.67	88.94	3.35
	Users B	1.47	0.58	86.80	2.70

station. After dark, however, the edge of the SDE moved even further south to other public transport stops, as well as to one of the railway stations. There were not only differences in dispersion between residents and users of the town, but also differences between Users A and Users B (Table 2). Since the walking possibilities are limited in an hourly time interval, the SDE ellipses for the rush hours covered a smaller area than the SDEs pertaining to longer periods. It was possible to compare both rush hour SDEs, however.

Our assumption that the pedestrian routes of users will show a lower degree of dispersion, and thus that they will be more compact and spatially concentrated, was confirmed only after dark and during the afternoon rush hour between 13:01-14:00, with the opposite tendency in daylight and during the morning peak at 7:01-8:00.

Figure 3: **Important (frequently visited) localities in the walking environment of the examined ward**



There were interesting differences in WAS dispersion when distinguishing residents from Users B. In all cases, the dispersion of residents reached higher values than for Users B. The results indicate that spatio-temporal walking patterns may be affected by the residence location of participants, as well as by the location of public transport stops and, in the afternoon, also by the location of pedestrian zones and shopping centres, as well as routes leading to these destinations. Regardless of the residential locations, the walking patterns were determined by the spatial distribution of schools. There was a difference in walking to public transport stops, where users walked more often than residents (Table 3).

Table 3: **The most frequently visited cells in daylight according to residential location**

Ranking	Cell no.	Number of visits		Description
		Sum	Per 1 resident or user	
Residents in daylight				
1	214	60	0.59	Pavements leading to schools, school locations, public transport stops
2	150	45	0.44	School locations, absence of public transport stops
3	183	34	0.33	Pavements leading to school, absence of public transport stops
4	177	24	0.24	The edge of a historical town centre close to school locations, absence of public transport stops
5	286	23	0.23	School locations, absence of public transport stops
Users in daylight				
1	214	109	0.57	Pavements leading to schools, school locations, public transport stops
2	150	76	0.4	School' locations, absence of public transport stops
3	148	74	0.39	Public transport hubs
4	177	58	0.3	The edge of a historical town centre close to school locations, absence of public transport stops
5	239	54	0.28	Pavements leading to school, public transport stops

Table 4: **The most frequently visited cells after dark according to residential location**

Ranking	Cell no.	Number of visits		Description
		Sum	Per 1 resident or user	
Residents after dark				
1	110	18	0.18	Square ("SNP Square") pedestrian zone, historical core
2	143	13	0.13	Square ("Štefan Moyses Square"), historical core
3	15	11	0.11	The biggest shopping centre
4-5	26	10	0.1	Smaller shopping centre, pavement leading to the biggest shopping centre
4-5	148	10	0.1	Public transport hubs
Users after dark				
1	15	17	0.09	The biggest shopping centre
2	148	14	0.07	Public transport hubs
3-4	53	10	0.05	Street leading to a square ("SNP Square"), public transport stops, pavement leading to a railway station
3-4	110	10	0.05	Square ("SNP Square") pedestrian zone, historical core
5	26	9	0.05	Smaller shopping centre, pavement leading to the biggest shopping centre

Discussion and conclusions

This study examined the differences in the walking activity of residents and other public space users in the central ward of Banská Bystrica (central Slovakia). Important findings were made when focusing on walking intensity and its spatio-temporal patterns during workdays.

In general, residents of the ward walked more than other public space users. This is in line with the results of Lavadinho (2006), who found that residents accounted for more than half of all public space users, regardless of their age. Lavadinho (2006), Namin et al. (2013), and Rahman et al. (2015) suggested that individuals who are more familiar with a certain public space tend to use it to a greater extent, as well as spending more time there. It is important to note,

however, that this study did not examine the time spent in the cell, only the number of movements through it. Sjolie et al. (2002) also found that the median distance that urban adolescents walked or cycled to school, as well as to regular activities, was greater compared than that of rural youths. Studies pertaining to the PA of adolescents according to urbanicity are inconclusive, however, with some showing no difference in PA (Booth et al. 2004; Felton et al. 2002; Plotnikoff et al. 2004; Springer et al. 2009), while others suggest that urban residents are less active (Liu et al. 2008; Springer et al. 2006). Comparability with PA-focused studies is questionable, however, as the studies above did not distinguish types of PA (no information on how much was walking), and it is also not clear where the PA was performed.

Residents of the ward only walked to a greater extent during afternoon hours and after dark, while differences until 13:00 were not significant. An average user also walked slightly more than an average resident during some of the morning time intervals. No conclusions can be drawn about school time, due to the generally lower walking activity and the related small amount of data available, but the differences became significant in the afternoon, when the walking activities were not related to school commuting. After 13:00, the participants all left the common fixed activity (school), and leisure activities began at the same time. Pospíšilová and Ouředníček (2011), who examined the spatio-temporal activity patterns of Prague students, had similar findings. Residents of Prague undertook outdoor evening activities to a greater extent than suburbanites, probably due to the worse public transport connections in suburban areas. The differences can be explained by users facing spatio-temporal constraints to a greater extent than residents (e.g., time loss in transport) and thus having different amounts of free time (Pospíšilová – Ouředníček 2011; Putnam 2001). Limited time budgets mean that the activities of non-residents must either be shorter or not carried out at all. An example is having less shopping time, and more time spent at home (Morris – Pfeiffer 2016). Similarly, Glaeser and Gottlieb (2006) found adult urban dwellers visiting museums, restaurants, concerts, and bars more than suburbanites**.** This may be similar to walking for leisure, for which suburbanites may not have enough time. Conversely, Morris et al. (2019) found city residents and suburbanites to carry out a similar amount and type of out-of-home activities, but urban dwellers walking more. Here it is important to mention that not only the journey between home and school, but also journeys between other destinations (e.g., malls or restaurants) are important in contributing to the PA of adolescents (Rainham et al. 2012).

Second, comparing comparison of the spatio-temporal walking patterns of residents and Users B (residing outside the town) found that the WAS of

residents was more dispersed in every time interval studied. This may be a result of Users B often traveling only to and from school, as suggested by Pospíšilová and Ouředníček (2011), who explained such results as due to less frequent public transport connections. Vich et al. (2017) alternatively showed that university staff had smaller activity spaces than students, due to smaller time budgets and less free time.

In general, the spatial walking patterns of participants were affected by residence, as well as by the location of schools, public transport stops, pedestrian zones, and shopping centres. Similarly, Millward et al. (2013) found shopping centres, bus stops, and places of daily attendance (in their case, workplaces) to be the most frequently visited destinations, but also a bank, bars, and grocers. Lin and Moudon (2010) found that schools and grocery stores were significantly related to walking. The highest concentration of urban facilities in Banská Bystrica was found in the historic city centre (Rišová – Pouš 2018), which is possibly due, as mentioned above, to the quarters built in the pre-socialist period being more able to adapt to commercialisation compared to other urban areas (Stanilov 2007). The edge of the studied area is of socialist origin, and less suitable for locating urban facilities.

The limitations of the research relate mainly to the specific age category of the respondents, whose members are linked by a common fixed activity – school attendance, which directly affects the spatio-temporal patterns of their walking activities. The spatio-temporal walking patterns presented are therefore applicable to this specific sample only and need to be interpreted accordingly. A second limitation is that the study only used a quantitative approach. For the needs of urban planning, it would be necessary to obtain data for all age categories, and it would be beneficial to provide explanations of individual motivations. Another limitation pertains to the mapping activity technique, and the grid pattern with numerically assigned cells. It is necessary to accept a certain spatial generalisation in relation to this, as it is not possible to record the exact routes of the participants. The time spent in a cell was also not considered, so an individual's actual walking may differ slightly from the walking intensity calculated in this study. It was important, however, for the study to provide a method of data collection that was easy for adolescents to undertake.

When formulating conclusions, it is important to remember that the spatio-temporal patterns of WAS can change not only in a day, but also due to the alternation of seasons. During the day the variability of WAS attributes can be affected by, for example, daylight and lighting conditions, temperature, and precipitation. As the data was collected in November and December, the effect of a short duration of natural daylight within a day, as well as weather typical

of the beginning of winter, can also affect WAS attributes. As the data was collected before the COVID-19 pandemic, the spatio-temporal patterns of adolescent walking were not affected by anti-pandemic measures. Finally, the research was located in a town with several social and morphological characterristics due to various historical stages of its construction, as well as its socialist past.

Its differences from the prevailing research located in generic Western cities means that the results of this study can be considered even more valuable. Importantly, the study filled a gap in the existing research by providing a glimpse into the spatio-temporal variations of walking activities for one of the most overlooked pedestrian age categories, while noting the role of their residential location. Another gap was filled by contributing to Central European public space research, which is often overlooked when examining public space, as well as by examining spatial behaviour in a post-socialist society, which is still gradually adapting to the "western" model of public space perception and its use. Nevertheless, there is still a need for further studies of this kind. In the future, it will be beneficial to examine the familiarity concept and its effect on the walking activity of individuals in more detail, as well as reasons behind choices of route.

Katarína Rišová *is a post-doctoral researcher at the Institute of Geography at Slovak Academy of Sciences. In her research, she focuses on the spatial behaviours of individuals as well as on the spatial analyses of the urban public space attributes, with a special emphasis on social justice.*

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