ASSESSMENT OF ENVIRONMENTAL DETERMINANTS OF PHYSICAL ACTIVITY: A STUDY OF BUILT ENVIRONMENT INDICATORS IN BRNO, CZECH REPUBLIC

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SUMMARY

Background: Research on physical activity in relation to obesity gradually becomes more focused on environmental determinants, which can potentially influence people's health choices. The present article addresses the topic of physical activity from a wider sociological perspective. Our pilot study was designed with the objective of testing the applicability of a method included in the EC 6th Framework Programme EURO-PREVOB, in the Czech context. The method examines specific determinants of the built environment that can have an impact on physical activity at the population level. In addition, the study aims to analyze possible differences in built environment indicators and their relation to the physical activity of people living in neighbourhoods with areas of varying socioeconomic status.

Methods: The field study was carried out in the city of Brno, Czech Republic, in 5 neighbourhood quintiles, i.e. areas divided according to the socioeconomic status of local residents. In each quintile, we evaluated the quality of the built environment according to the quality, aesthetics and safety of segregated cycle facilities, playgrounds/playing areas, public open spaces, marked road crossings and pavements as well as signs of incivilities and devastation.

Results: Between the five quintiles, significant differences were found in the quality of parks and playgrounds/playing areas, pavements, marking of pedestrian crossings, and in general aesthetics, i.e. signs of incivilities and devastation of the built environment. No differences were found in the quality and use of cycle facilities.

Conclusions: The method we used for the evaluation of the built environment proved highly applicable in Czech populated areas. Monitoring of built environment indicators in the Czech Republic should provide a basis for health maps, showing potential associations between the prevalence of high-incidence, non-infectious diseases and various social determinants of physical activity. This information might help in achieving an improvement in these determinants at a community level and promoting an increase in physical activity at the population level.

INTRODUCTION

Recent publications on physical activity (PA) in relation to obesity prevention often mention environmental determinants as potential factors influencing people's healthy choices regarding both intentional and non-intentional PA (1–3). One of the principal social determinants is the built environment, which includes all man-made structures such as homes, schools, workplaces, parks and open-space recreation areas, playgrounds/playing areas, greenways, transportation systems, and motor vehicles (4). Recent research has provided substantial evidence for the link between the visual appeal of the built environment, population density, street connectivity, destination accessibility, walking and cycling environment, safety and aesthetics of playgrounds/playing areas, the quality and safety of pedestrian crossings and pavements, and the amount of PA at the community level (5–8). The same is also true for studies held in the Czech environment (9–11). Numerous studies have demonstrated that PA as a part of a healthy lifestyle is more common in people residing in neighbourhoods with high socioeconomic status (SES), and is associated with the quality of the built environment (12, 13). PA at the population level is affected, for example, by the density, number, safety and aesthetics of public transport stops. However, such factors have opposing effects in different communities: in high SES neighbourhoods, low number of bus/tram stops leads to an increase in car use; in low SES neighbourhoods, on the other hand, it results in more unintentional PA (14–16). Several findings have indicated that the safety and cleanliness of pavements and the quality of road crossings as well as the overall cleanliness of public spaces might increase the amount of PA as well. PA in children is unquestionably

influenced by the pleasant appearance and safety of playgrounds (17–21). In contrast, traffic volume has been shown to be inversely related to the local residents' PA (22, 23). Still, it is often difficult to identify the indicators in the built environment that might be true causal factors of PA (24–27).

Keeping this issue in mind, our pilot study was designed to test the applicability of the method proposed by the EC 6th Framework Programme EURO-PREVOB in the Czech context. The method examines specific determinants of the built environment that can affect physical activity at the population level (28). The aim of the study was to analyze possible differences in indicators of the built environment and their relation to the PA of people living in neighbourhoods with areas of high and low SES.

MATERIALS AND METHODS

The study was conducted in spring 2012 in five community areas in Brno. The selection of territorial units (so-called "basic settlement units") was based on two sources. The first source was the 2001 census data from the city of Brno. A secondary analysis of the data file (which mapped educational characteristics of the population, unemployment figures, household amenities and the quality of the housing stock) allowed us to obtain the "index of socioeconomic status of the population" divided into five quintiles (29, 30).

The second source of our selection of territorial units in Brno entitled "Factor analysis – example of Brno" featured a study by Ondřej Mulíček that focused on internal socioeconomic differentiation in Brno (31). This study also relied on census data from 2001, and measured socioeconomic status of the residents of Brno, which combined educational and occupational characteristics of the population and was supplemented by data on household equipment, housing quality and the nature of the housing stock. This study also divided the "basic territorial units" of Brno into five quintiles. For EURO-PREVOB, and consequently for our ongoing study, sites were selected to represent each of the five quintiles of socioeconomic status (ranging from the highest to the lowest SES). Both sources showed an overlap.

The built environment in each of these neighbourhoods was evaluated according to the indicator criteria adopted from the EURO-PREVOB project (32) conducted in 2008–2009, which was devoted, among other things, to designing an adequate assessment method. The method was tested in eleven countries, including the Czech Republic. In 2008, the areas selected for the EURO-PREVOB project in Brno were supposed to be approximately 2.5 km^2 each, i.e. ideally they would be squares with a side length of 1.6 km (28). For the cities assessed within the EURO-PREVOB project in France, Slovenia, Latvia, Turkey, Denmark etc. an area of 0.25 km^2 was chosen. In our present study, the areas were reduced to 1 km^2; the neighbourhoods, however, remained the same in terms of their location. Monitored sites with an area of 1 km^2 were selected. By using street lines as boundaries, we approximated a relatively square shaped area. Inconsistencies, such as the quality of pedestrian crossings and public open spaces, occurred in cases where examined neighbourhoods were bordering quintiles that belonged to a different SES group, which prompted us to adjust the methodology for assessment of the built environment so that the examined area was reduced to 1 km^2. This way, the obtained data would have greater homogeneity and thus greater validity (33).

The selection included traditionally settled areas around the historical city centre as well as more recent housing developments on the periphery. Communities living in these uptown areas differ from those residing in the city centre in visible attributes such as car (garage), dog and/or garden ownership.

In general, we analyzed the areas in the neighbourhoods where people live, spend their time, and through which they commute. We focused on the following indicators of environment quality: segregated cycle facilities (cycle lanes, cycle paths, shared-use paths etc.), parks and playgrounds/playing areas, safe pedestrian crossings, and visual appeal/degree of devastation of the built environment as a whole. The obtained data was subsequently assigned grades ranging from 1 to 4 to qualitatively describe the environment, with 1 and 4 being the best and worst quality, respectively (Figures 1–6). Direct observation and photographic documentation was used. The indicators were graded by two trained, independent observers, who received model sketches to use as templates for the grading (1 to 4). The observation and grading took place in the field and was led by the authors of the study, who were participants of the EURO-PREVOB project and have experience with the evaluation of monitored indicators. Observation and evaluation of the envi-

Fig. 1. *Examples of classification of the quality of cycle facilities. (From the left, grading 1–4).*

Fig. 2. *Examples of classification of the quality of public open spaces. (From the left, grading 1–4).*

Fig. 3. *Examples of classification of playgrounds/playing areas. (From the left, grading 1–4).*

Fig. 4. *Examples of classification of the quality of marked road crossings. (From the left, grading 1–4).*

Fig. 5. *Examples of classification of the quality of pavements. (From the left, grading 1–4).*

Fig. 6. *Examples of classification of attractiveness and devastation. (From the left, grading 1–4).*

ronment aesthetics was conducted so that primarily cleanliness, tidiness and usefulness would be taken into account. At the end of each observation day, the observers compared their results with each other and discussed the discrepancies to reach a consensus.

The following parameters were selected as potential factors determining the accessibility of PA for local residents: segregated cycle facilities (quality, length, obstructions and the level of bike traffic), public open spaces – especially parks and playing fields (cleanliness and maintenance, size, sports facilities and playgrounds), pedestrian crossings (safety and marking), pavements (quality, cleanliness and exclusive use by pedestrians), and overall appearance of the location (physical incivilities and degree of devastation).

Differences between the quintiles in terms of numbers of segregated cycle facilities, marked pedestrian crossings and playgrounds/playing fields, and the differences in the quality of individual indicators were tested using the Kruskal-Wallis test.

RESULTS

The differences in grading of the individual quality indicators of the built environment are shown in Tables 1–9.

Cycle Facilities

Differences in the numbers of segregated cycle facilities (lanes, paths, shared-use walkways, etc.) could not be statistically tested due to the generally low number of such facilities in each quintile. For the same reason, the quality and other attributes of cycle facilities could not be compared (Table 1).

Since cycle facilities in all five quintiles were completely passable and without obstructions, there were no differences to be tested (Table 2 and 4).

Differences in the use of the cycle facilities could not be tested due to insufficient data (Table 3).

Public Open Spaces and Playgrounds/Playing Areas

Differences could not be tested due to insufficient data (Table 5, 6).

Due to the ordinal scaling of indicator ratings (1 to 4), differences between the neighbourhood quintiles were analyzed using the Kruskal-Wallis test. The differences in the quality of public open spaces among the neighbourhood quintiles were statistically significant ($p < 0.01$), with Quintiles 1 and 2 showing the highest quality, and Quintile 5 showing the poorest quality. A similar pattern was observed with playgrounds/playing areas ($p < 0.05$).

Table 1. *Categorization (grading) of segregated cycle facilities*

Area	Cycle facility category			Total
	1	2	3	
Quintile 1	2	0	0	2
Quintile 2	1	0	0	1
Quintile 3	0	1	0	1
Quintile 4	2	1	1	4
Quintile 5	0	1	0	1
Total	5	3	1	9

Table 2. *Passability and continuity of segregated cycle facilities*

Area	Cycle facility continuity	Total
	Yes	
Quintile 1	2	2
Quintile 2	1	1
Quintile 3	1	1
Quintile 4	4	4
Quintile 5	1	1
Total	9	9

Table 3. *Presence of cyclists on the path/lane (cycle traffic volume)*

Area	Cyclists visible		Total
	No	Yes	
Quintile 1	1	1	2
Quintile 2	0	1	1
Quintile 3	1	0	1
Quintile 4	3	1	4
Quintile 5	1	0	1
Total	6	3	9

Table 4. *Obstructions on the cycle path/lane*

Area	Obstructions on the path/lane		Total
	No	Yes	
Quintile 1	2	0	2
Quintile 2	1	0	1
Quintile 3	0	1	1
Quintile 4	3	1	4
Quintile 5	1	0	1
Total	7	2	9

Table 5. *Quality of public open spaces*

Area	n	Min.	Max.	Median
Quintile 1	8	1	3	1.5
Quintile 2	14	1	3	2
Quintile 3	9	1	4	3
Quintile 4	11	2	4	3
Quintile 5	14	3	4	4
Total	56	1	4	3

n – number of public open spaces in each quintile, Min. – minimum rating (highest grade), Max. – maximum rating (lowest grade)

Table 6. *Quality of playgrounds/playing areas*

Area	n	Min.	Max.	Median
Quintile 1	3	1	3	1
Quintile 2	7	1	3	1
Quintile 3	5	1	4	3
Quintile 4	9	2	4	3
Quintile 5	3	3	4	4
Total	27	1	4	2

n – number of playgrounds/playing areas in each quintile, Min. – minimum rating (highest grade), Max. – maximum rating (lowest grade)

Table 7. *Quality of pedestrian crossings*

Area	n	Min.	Max.	Median
Quintile 1	27	1	4	2
Quintile 2	39	1	4	2
Quintile 3	62	1	4	2
Quintile 4	13	2	4	2
Quintile 5	48	1	4	3.5
Total	189	1	4	2

n – number of marked pedestrian crossings in each quintile, Min. – minimum rating (highest grade), Max. – maximum rating (lowest grade)

Table 8. *Quality of pavements*

Area	n	Min.	Max.	Median
Quintile 1	18	1	4	1.5
Quintile 2	8	1	4	1
Quintile 3	9	1	3	1
Quintile 4	16	1	4	3
Quintile 5	28	1	4	2.5
Total	79	1	4	2

n – number of pavements in each quintile, Min. – minimum rating (highest grade), Max. – maximum rating (lowest grade)

Pedestrian Crossings

Due to the ordinal scaling of indicator ratings, differences in the quality of pedestrian crossings were analyzed using the Kruskal-Wallis test. Significant differences were observed between the quintiles ($p < 0.05$). Crossings of the poorest quality were found in Quintile 5 (md = 3.5); in all other quintiles, the quality was comparable (Table 7).

Pavements

Due to the ordinal scaling of indicator ratings, differences in the quality of pavements were analyzed using the Kruskal-Wallis test. Differences between the quintiles were significant ($p < 0.05$) – quality of pavements was rated as highest SES in Quintiles 2 and 3, and as lowest SES in Quintile 4 (Table 8).

Table 9. *Tangible signs of unattractiveness*

Area	n	Min.	Max.	Median
Quintile 1	3	2	2	2
Quintile 2	2	2	3	2.5
Quintile 3	2	3	3	3
Quintile 4	5	2	4	3
Quintile 5	14	2	4	4
Total	26	2	4	3

n – number of signs of unattractiveness in each quintile, Min. – minimum rating (highest grade), Max. – maximum rating (lowest grade)

Due to the ordinal scaling of indicator ratings, differences between the quintiles were tested using the Kruskal-Wallis test. Tangible unappealing features were least visible in Quintiles 1 and 2 and most visible in Quintile 5 (where they were also found in largest numbers). The differences were significant ($p < 0.01$) (Table 9).

DISCUSSION

Segregated Cycle Facilities (Cycle Lanes, Cycle Paths)

Our assumption regarding this indicator in relation to the socioeconomic attributes of the residential area was that the density and/or length of cycle facilities would be greater in wealthier quintiles while in poorer neighbourhoods such facilities would be scarce or completely lacking (34). However, the results show that the relationship is very weak and does not seem causal. This is mainly because in the Czech Republic cycle facilities are not usually built due to the demand of residents living in the neighbourhood through which the path or lane leads. Rather, they are constructed in areas where terrain and local traffic solutions enable it or simply to provide a connection between other areas with cycle facilities, which may be required on various, sometimes merely political grounds. At present, the idea of cycle path construction or cycle lane marking on public demand does not seem realistic. Moreover, segregated cycle facilities (e.g. cycle lanes, cycle paths etc.) in the Czech Republic are traditionally viewed as leisure facilities rather than as a standard means of transport to school or workplace. For this reason, they are often built as shared-use paths or greenways in satellite towns and lead to open non-urban areas. Although their primary purpose is to provide an opportunity for cycling (and, in many cases, other activities, such as inline skating), it is cycling in the sense of "going for a ride" rather than "moving from one place to another". The presence of cycle paths in the built environment therefore mostly benefits intentional PA and does not really contribute to unintentional PA.

Parks and Playgrounds/Playing Areas

In contrast to the number and quality of segregated cycle facilities, which are not expected to be directly related to the SES of the neighbourhood, we assumed the quality of parks and playgrounds to be closely associated with the ranking of the quintiles (19, 35, 36). Since parks and playgrounds serve important cultural and social functions, their appearance and quality are both influenced by the community life in the immediate proximity. However, observational support of this reasoning was not completely straightforward either, as appreciable differences were only found between the wealthiest Quintiles 1 and 2 and the poorest Quintile 5. Rather than going to public parks regularly, people living in single-family houses and villas often prefer to spend their outdoor time in their own gardens, or visit exclusive leisure facilities outside the neighbourhood (golf courses, playing fields, riding halls, tennis courts, etc.). On the other hand, parks are especially popular among the middle and lower social classes. SES of the neighbourhood is usually reflected in tangible signs of physical incivilities, for which parks and playgrounds literally serve as a case in point. From the economic perspective, parks and public playing grounds can be viewed as providing certain competition for commercial facilities such as fitness-centres and gyms. Dilapidation of public open spaces further diminishes the public's interest in their maintenance, and draws potential habitués to more attractive and upper-class places offering paid services.

Pedestrian Crossings

Marked and maintained road crossings complemented with traffic lights are significant indicators of the built environment. Safe traffic with a high degree of "walkability" reflects the quality of residential environments (37, 38). As stated by Frank et al., Giles-Corti and Donovan, and Marmot "the built environment interacts with the social environment, according to socioeconomic status; the lower the economic status, the lower the environment quality" (39–41). We expected better-quality and more attractive built environment in higher SES neighbourhoods compared to poorer ones. Somewhat more complicated is the issue of number/density of road crossings. In higher SES residential areas, there is so little traffic that streets can be crossed relatively safely at any point. While the presence of marked pedestrian crossings certainly serves a protective function (pedestrians right-of-way), it is also restricting, as pedestrians cannot cross the road at any point anymore if there is a marked crossing nearby. This may create complications especially for the elderly, some of whom might have mobility problems, and for whom every additional metre of walking could become a source of discomfort. In our study, road crossings with the worst grading were those in Quintile 5; the other four quintiles did not differ significantly from each other.

Pavements

Pavements can be seen as an integral part of the built environment (42). Their quality, attractiveness and safety complement the overall quality of housing in the neighbourhood (43) and are crucial factors in PA such as jogging. In the Czech Republic, the quality of pavements is usually directly associated with the SES of local residents. Whereas pavements in the higher SES neighbourhoods are well-maintained and unoccupied by parked cars, which might take up a substantial part of the space originally intended for pedestrians, in the lowest SES neighbourhoods the situation is exactly the opposite. Pavements in rich neighbourhoods are neither covered with cigarette butts and litter nor animal excrements. In stark contrast, in the lowest SES neighbourhoods in the Czech Republic, pedestrians are often barely able to use the pavements at all, as they

are occupied by parked cars to such an extent that people walking down the street are inevitably forced to brush their clothes against the cars. This observation applies predominantly to urban areas used primarily for housing, and is not valid for downtown areas and city centres where aesthetics is determined mainly by owners/operators of office buildings and shops. We find it extremely likely that this issue has a negative impact on, for example, jogging or running opportunities in the vicinity of one's residence. Because of this, we consider pavements as one of the most significant quality indicators of the built environment in the present study, which has found significant differences in the quality of pavements in the five quintiles. It must be noted that the median grade in Quintile 1 was reduced due to ongoing road works, not incivilities.

Overall Attractiveness, Physical Incivilities and Devastation

Due to the political and social situation that was established in the 1950s and continued up until the early 1990s, the expression "good address" was not used so frequently in the Czech Republic – it only came to be used in the late 1990s. In spite of this, differences in the aesthetics of the built environment, whether they are appealing or showing visible signs of damage, are clearly visible between the various neighbourhoods. Damage can be caused either by intentional incivilities or poor maintenance by the members of the community who are indifferent to the community surroundings and fail to carry out immediate repairs when needed. On the contrary, an area visual appeal is typically a result of active striving for beautification of the built environment. We expected the appeal to increase with the SES of neighbourhood (44), although it must be mentioned that appeal in this respect should not be confused with tastefulness. Rather, what we mean by appeal is general neatness, functionality and cleanliness. Because we used features with a tangible lack of appeal as a measure of aesthetics in the present study, a rating of 1 was not included in the scale. In accordance with our expectations, differences between the quintiles were significant, with the highest degree of incivilities and disrepair found in Quintile 5.

With regard to our hypothesis on the dissimilarities between different SES neighbourhoods in terms of the quality of various indicators of the built environment, the greatest limitation of the employed methodology was probably the issue of quintile selection. In case of our survey, site selection was based on the results of two independent works, which categorized the Brno neighbourhoods based on an analysis of census data. Analyzed territorial units, so-called primary residential units, are relatively small and it was difficult to find homogeneous areas with the required dimensions. One thing to keep in mind is that in the "post-communist" countries, the built environment typically lacks a clear social and cultural structure to reflect visible and tangible attributes of sociologically structured neighbourhoods. In such neighbourhoods, the built environment is understandably shaped mainly by social phenomena characteristic of low-income groups. This fact, in turn, may reflect the extent to which opportunities for PA are used by the local residents. Decreased attractiveness of playing areas and public open spaces, signs of vandalism, etc., might drive away even those residents (and their children) who would otherwise be interested in using open spaces for exercise and other physical activity.

It is important to clarify that our results are objective observations that cannot be compared with data obtained through subjective measures such as questionnaires, which are used for the measurement of the public's perceptions and evaluations of individual indicators of the built environment (11, 45). Subjective assessment might be inconsistent for various reasons, for example, obese individuals might perceive the level of pedestrian friendliness of various areas in the neighbourhood differently from individuals who are physically fit (23, 24). Thus, objective assessment of the built environment will always serve as a useful complement to subjective measures. The more objective data used (e.g. census, GIS, unemployment statistics etc.), the greater the relevance of the evaluation of neighbourhood quality.

Limitations

In terms of international comparability the most important limit for the study is the selection of monitored sites, as described above. The natural limit of site selection (and consequently of our study) is the fact that the highest SES quintile as well as the lowest one will always differ from country to country.

CONCLUSIONS

Modifying the EURO-PREVOB methodology (1.0 km² instead of 2.5 km² quintile size) when assessing built environment indicators in Brno proved to be more accurate and appropriate for practical use.

In the event that the census data is of limited suitability, it is possible to abandon the SES quintile categorization completely in further research and study the indicators of the built environment independently of this categorization. Since the information value of individual indicators differs – for example, cycle facilities are influenced by factors other than pavements and playgrounds – it is necessary to select indicators carefully with respect to the research question so that the answers obtained are truly relevant to the topic of interest.

Documentation of the built environment indicators in relation to a population's PA should serve as a starting point for the construction of public health community maps, which are good tools for monitoring potential associations between the prevalence of high-incidence non-infectious diseases and various social determinants of PA. This information could be used for further improvement of these determinants at a community level, which, in turn, might help increase physical activity at the population level.

Conflict of Interest

None declared

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