Active commuting of the inhabitants of Liberec city in low and high walkability areas

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Background: Active commuting in terms of everyday transport to school or work can have a significant effect on physical activity. Active commuting can be influenced by the environment, and examples from abroad show that current environmental changes tend mostly to promote passive forms of commuting. A similar situation of decreasing active commuting might be expected in the Czech Republic. However, little information has been published to date about the issue of active commuting among the inhabitants of our country. **Objective:** The main objective of the present study is to describe the active commuting patterns of the inhabitants of Liberec city in low and high walkability areas. **Methods:** A total of 23,621 economically active inhabitants or students of Liberec city aged 6–87 years (34.77 ± 14.39) participated in the study. The data about commuting were retrieved from the national Population and Housing Census of 2011. Geographic information systems were used to objectively analyze the built environment and to calculate the walkability index. **Results:** Active commuting to/from school or work is used by 17.41% of inhabitants. Active commuting is dominated by walking (16.60%) as opposed to cycling (0.81%). Inhabitants who lived in high walkability areas were more likely to actively commute than those living in low walkability areas (*OR* = 1.54; 95% CI [1.41, 1.68]). **Conclusions:** This study confirmed the findings of international studies about the effect of the built environment on active commuting among Liberec inhabitants. Active commuters are often those living near or in the city center, which is characterized by high walkability. In Liberec city, walking as a means of active commuting significantly prevails over cycling. One of the reasons might be the diverse topography of the city and the insufficiently developed cycling network.

Keywords: built environment, physical activity, transport, walking, bicycling, GIS

Introduction

The beneficial effect of regular physical activity (PA) on human health has been discussed previously (Bouchard, Blair, & Haskell, 2007; Reiner, Niermann, Jekauc, & Woll, 2013). However, many countries, including the Czech Republic report a negative trend of decreasing overall PA (Brodersen, Steptoe, Boniface, & Wardle, 2007; Inoue et al., 2011; Medina, Janssen, Campos, & Barquera, 2013; Sigmundová, El Ansari, Sigmund, & Frömel, 2011).

One suitable way to promote overall PA is the development of active commuting (AC) (Faulkner, Buliung, Flora, & Fusco, 2009; Sallis, Frank, Saelens, & Kraft, 2004). A number of studies have confirmed that AC is a significant component of overall PA (Carver et al., 2011; Cooper, Andersen, Wedderkopp, Page, & Froberg, 2005; Cooper, Page, Foster, & Qahwaji, 2003; Kudláček, Nováková Lokvencová, Rubín, Chmelík, & Frömel, 2013; Roth, Millett, & Mindell, 2012). This fact applies to children and youth in terms of their everyday commuting to school but also, to a large extent to adults in terms of commuting to work (Yang, Panter, Griffin, & Ogilvie, 2012).

The decreasing levels of PA (McDonald, 2007; van der Ploeg, Merom, Corpuz, & Bauman, 2008) are associated with a significantly decreasing trend in the use of active forms of commuting (Carver et al., 2011). Research suggests that the highest proportion of AC includes walking and cycling, while other forms of AC (e.g., inline skating, scootering or skateboarding) represent an insignificant proportion of AC (Bringolf-Isler et

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al., 2008). To successfully promote AC, it is important to understand the factors that influence this behavior. From the perspective of the ecological model of active living (Sallis, Owen, & Fisher, 2008), on which this study is based, it appears that the choice of an individual to use AC is influenced by various factors, particularly by personality traits, social interactions and environmental conditions.

The promotion of AC in the built environment is a comprehensive issue and is currently not fully explained. The effect of the built environment on AC has only been demonstrated by partial studies thus far. The research has confirmed that attributes of the built environment might have a positive or negative effect on the PA behaviors of the inhabitants (Dygryn, Mitas, & Stelzer, 2010; Frank, Schmid, Sallis, Chapman, & Saelens, 2005; Humpel, Owen, & Leslie, 2002; McCormack, Giles-Corti, & Bulsara, 2008; Panter, Jones, van Sluijs, & Griffin, 2010).

To specify the built environment the term "walkability" is often used (Frank et al., 2005). The strongest environmental attributes defining walkability are residential density, street connectivity and the land use mix (Leslie et al., 2007). Individuals who live in areas with a high land use mix, high connectivity and high residential density (high walkability) are more likely to use walking or cycling as a mode of commuting (Saelens & Handy, 2008). In recent decades, changes in the environment (especially in the built environment, such as the excessive building of infrastructure for motorized means of transportation and rural residential construction) tend to favor passive forms of commuting and sedentary behaviors (Leslie, Kremer, Toumbourou, & Williams, 2010; Panter, Jones, & van Sluijs, 2008). Due to the current socioeconomic changes, a similar trend might be expected in our country.

Thus far, no study has comprehensively identified of the AC of the inhabitants of a specific city in the Czech Republic. Therefore, the main objective of this study is to characterize the AC patterns of the inhabitants of Liberec city in low and high walkability areas.

Methods

Participants

This study includes data from a total of 23,621 respondents (11,972 men and 11,649 women). All respondents were economically active inhabitants or students of the statutory city of Liberec aged 6–87 years (34.77 ± 14.39) who took part in the national Population and Housing Census of 2011 in the Czech Republic. Of the initial 24,195 respondents, 574 (2.37%) were rejected due to incomplete data. Detailed information about the representative sample is shown in Table 1.

Table 1
Characteristics of the representative sample (N = 23,621)

Attribute	*n*	%
Gender		
Male	11,972	50.68
Female	11,649	49.32
Age		
6–18	3,123	13.22
19–35	9,800	41.49
36–50	6,723	28.46
51–65	3,706	15.69
66–87	269	1.14
Education		
Under 15 years	1,986	8.41
No formal	18	0.08
Primary	2,440	10.33
Secondary	12,679	53.67
Higher	6,498	27.51
Walkability		
Low	4,040	17.10
High	16,206	68.61
Commuting		
Active	4,113	17.41
Passive	19,508	82.59

Procedures

The decisive moment of the Population and Housing Census of 2011 was midnight from Friday 25 to Saturday 26 March 2011. Selected demographic data (gender, year of birth, education, place of residence and others) and data relating to the AC of economically active inhabitants or students were retrieved on application for the purposes of scientific research to the Czech Statistical Office. The questions related to AC were as follows: "*Specify the mode(s) of transportation that you usually use on a single way to school or work.*" (answers: bus, city transport, car – driver, car – passenger, train, bicycle, motorcycle, other and none – only walking) and "*Specify how long it takes you one way to school or work.*" (answers: 14 min or less, 15–29 min, 30–44 min, 45–59 min, 60–89 min and over 90 min).

For the purposes of the study, AC is understood as commuting by walking (no means of commuting used) or cycling. Other means of commuting propelled in ways other than by a person's own power (passenger car, motorcycle, public transport, bus, train, a

combination of the previous including AC, and others) are considered passive commuting.

For the analyses and calculations of the walkability indexes, the study used geographic information systems (GIS) that allow the retrieval, storage, analyses and visualizations of spatial data, i.e., geodata.

By editing the geodata map layers in the GIS in this study, it is possible to determine the "walkability" of the environment (i.e., whether the environment directly or indirectly supports PA). High walkability signifies an environment friendlier to forms of active commuting (such as walking and cycling). Most studies assess walkability according to street connectivity, residential density and the land-use mix, which experts believe to be most influential. Originally, these correlates were analyzed separately (Boarnet & Sarmiento, 1998), although they were later grouped into a single "walkability index" (Adams et al., 2014; Frank et al., 2010; Frank et al., 2005).

The walkability index in our study was adapted from international experience (Frank et al., 2010; Van Dyck et al., 2010). Individual map layers are expressed by standardized z-scores as independent indices. The following formula was used to determine the walkability index: walkability = (2 × street connectivity) + (residential density) + (land-use mix). According to the results of the walkability index, the areas were divided into deciles and classified as follows: 1–4 low walkability and 7–10 high walkability. As a result of the environmental influence of extreme walkability values on AC, the study excludes analyses of areas in the 5–6 deciles.

All calculations of the walkability index and all map layers were processed using ArcGIS software (Version 10; Esri, Redlands, CA, USA).

Statistical analysis

The arithmetic mean and standard deviation were used for the description of the results of the Population and Housing Census of 2011. A logistic regression was applied to express the association between AC and area walkability. Differences in the proportions of respondents with varying levels of AC in diverse walkability contexts and demographic factors were tested using the Chi-square test. All analyses were performed with the alpha value set at .05. All statistical analyses were performed using SPSS software (Version 19; IBM Armonk, NY, USA).

Results

The walkability index of Liberec city determined for individual cadastral areas suggests that the high walkability areas are generally in the city center, and the city outskirts are characterized by low walkability (Figure 1).

The percentages of AC in the cadastral areas of the city (Figure 2) confirm the positive effect of high walkability on AC. The highest proportion of AC is in the city center, where almost 29% of inhabitants use active forms of commuting. In contrast, in the outskirts the proportion of AC is mostly below 10%.

These facts are also supported by the results presented in Figure 3, i.e., we observed significant differences between the proportion of AC and other means of commuting in low (12.52%) and high walkability (20.34%) areas ($\chi^2 = 95.77$, *df* = 1, *p* < .001). Logistic regression confirmed that inhabitants living in high walkability areas are more likely to use AC than those
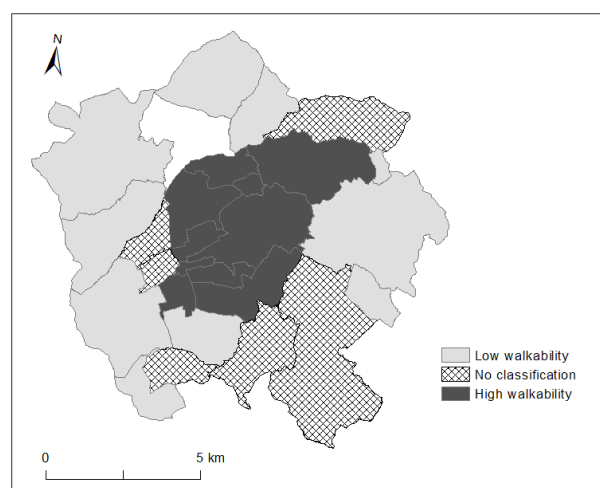

Figure 1. A cartogram of the walkability of Liberec city in the cadastral areas
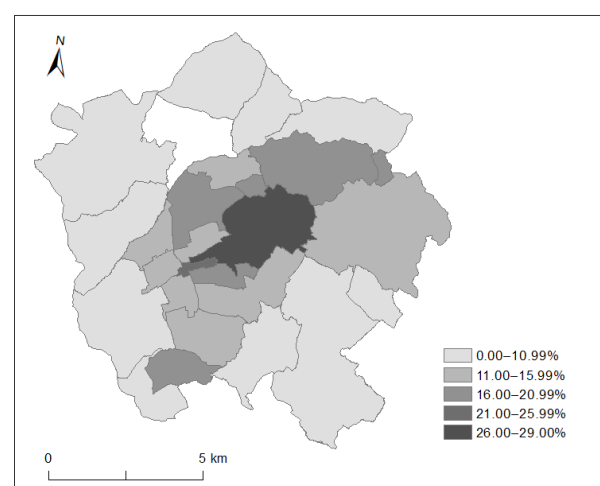

Figure 2. A cartogram of the proportions of active commuters among the inhabitants of Liberec city in the cadastral areas

living in low walkability areas (OR = 1.54; 95% CI [1.41; 1.68]; p < .001). Only 17.41% of the respondents report that they use an active form of commuting to school or work. The dominant form of AC was walking (95.36% of respondents), and the remaining proportion was represented by cycling (4.64% of respondents).

Figure 4 confirms the assumption of more frequent AC in high walkability areas compared to low walkability areas. Figure 4 also presents the greater variation in women in terms of AC in low and high walkability areas. This amounts almost to a 100% increase compared to men.

Figure 5 shows that the inhabitants of the city actively commute from home to school or work if it is easily accessible. In cases of 30-minute accessibility, AC is used by approximately 90% of all respondents using active forms of commuting. With increasing commuting time, AC steeply decreases. In cases in which accessibility exceeds 1 hour, the use of active forms of commuting is very low (0.49%). In terms of passive commuting, the time variability is higher. In cases

of 30-minute accessibility, approximately 72% of the inhabitants use passive commuting to school or work, or over 7% reported that their commuting time exceeds one hour.

The results of the study imply (Figure 6) that higher education increases the number of the inhabitants of Liberec city using AC as a form of commuting. AC as a form of commuting was observed in 11.11% of individuals without formal education (including those with unfinished primary education), whereas the proportion of AC in those with a university degree was 17.76%. However, the differences were not statistically significant (χ^2 = 0.54, df = 1, p = .46). The analysis did not include individuals under 15 years of age.

Discussion

The walkability distribution map of Liberec city shows the differentiated nature of walkability within the defined area (walkability decreases from the center
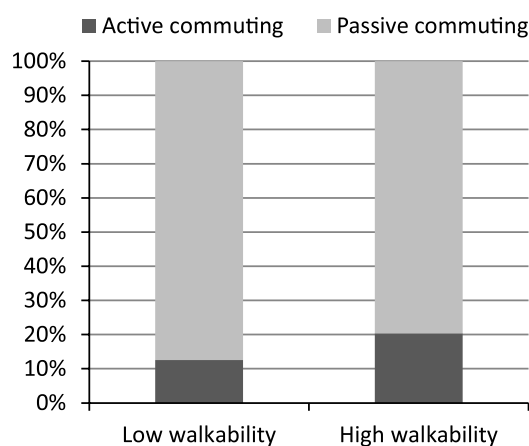

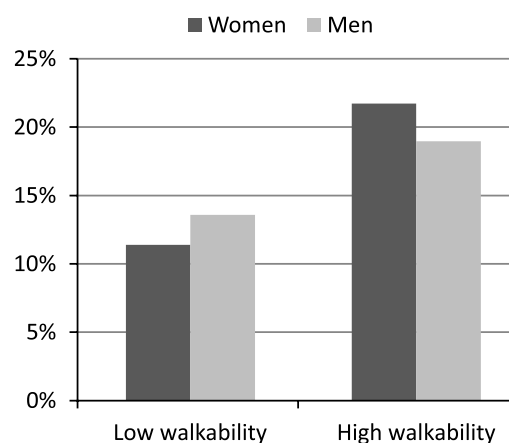*Figure 3.* The proportion of active and passive commuting by walkability

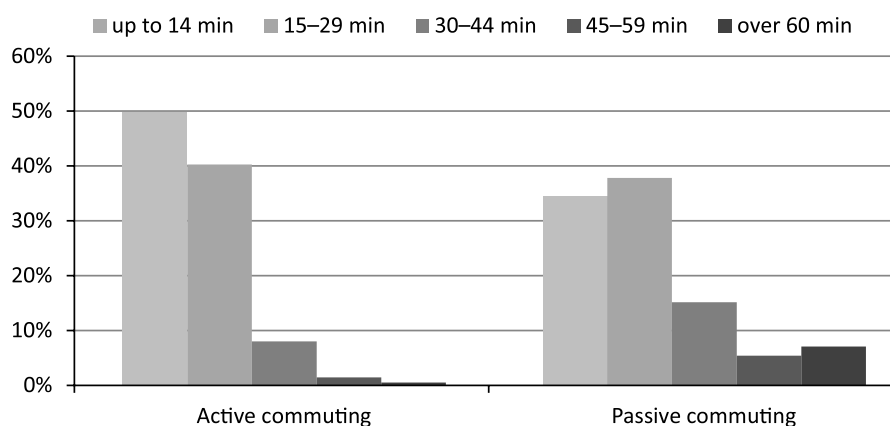*Figure 4.* Active commuting stratified by sex and walkability

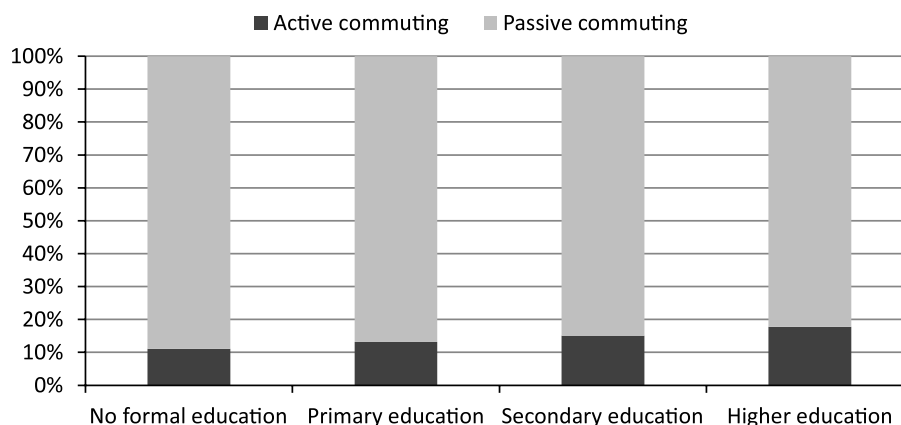*Figure 5.* The duration of commuting by type of commuting

Figure 6.   The proportion of active and passive commuting by education

towards the outskirts). This is consistent with the findings and results gathered in other studies (Christiansen, Madsen, Schipperijn, Ersbøll, & Troelsen, 2014; De Meester et al., 2012; Frank et al., 2010; Freeman et al., 2013). Adams et al. (2014) concluded that areas with high walkability are characterized by an accumulation of a large number of inhabitants and higher commuting accessibility (e.g., Hong Kong or Bogota in Colombia).

Our findings are in line with those of other research studies (Christiansen et al., 2014; Freeman et al., 2013; Grasser, Van Dyck, Titze, & Stronegger, 2013), which confirmed that higher territorial walkability increases the AC of the inhabitants. The average proportion of AC among the inhabitants of Liberec city (17%) is low compared with a study of Swedish adults (22.2%), which included a total of 16,705 individuals aged 18–80 years (Lindström, 2008). However, the average values of AC in working adults aged 18–65 years from an Australian study (6%) (Merom, Miller, Lymer, & Bauman, 2004) and a Canadian study (11%) (Craig, Brownson, Cragg, & Dunn, 2002) indicate superior levels of AC in the Liberec population. Each country (or even each city) seems to have its own specific qualities, and it makes sense to address the issue of AC in the context of the PA of the population with respect to local cultural, historical, economic and geographical status. These are some specific facts that we should try to positively influence as much as possible. The main reason for AC is that more than 77% of the respondents (77.03%) commute to school or work within the Liberec city (not shown in the results), which provides great potential for AC. Of the remaining respondents, 16.43% commute to a different municipality on a regular basis (3.76% weekly and 0.79% monthly).

Yang et al. (2012) revealed that in Cambridge, which is a city with the highest proportion of AC in Great Britain, 28% of active commuters use bicycles on a daily basis. In other cities in Great Britain, the amount of cycling commuters is approximately 3%. Similar result was revealed in a Spanish study (Chillón et al., 2013) in which 2% of adolescents were cycling to school in 2006–2007, and in a US study (Buehler & Pucher, 2012) in which approximately 2% of adults were cycling in selected cities (e.g., Seattle 2.5%, Washington 2.0%, Oakland 1.9%, Tucson 1.8%) of adults in 2006–2008. Compared with these results, the 0.81% of active cycling commuters makes Liberec a very below-average city in terms of cycling. One of the reasons might be the diverse topography of the city and the insufficiently developed cycling network.

Our results are in agreement with the findings from another study indicating that almost half of participants (40.4%) commute to work for less than 15 minutes (Lindström, 2008). It has been demonstrated that destination accessibility within 30 minutes is convenient for the use of AC as a means of commuting among 90% of all respondents.

We also observed that individuals aged 6–18 years use active forms of commuting more often (almost 30%) compared to older population groups (approximately 15%) (not shown in the results). A significantly higher relative proportion of AC was observed in children attending primary school, which was also confirmed in other studies. For example, in Great Britain more than 60% of children actively commute to primary schools (Cooper et al., 2003). In contrast, in the United States of America, the percentage of active commuters has decreased from almost 50% in the 1970s to 12.9% currently (McDonald, 2007). In Liberec in 2011, AC was used by 36.51% of children aged 6–15 years, which is a positive finding. Despite this fact, we still need to monitor the trends of changing behaviors and habits of children and adolescents and modify built environment and policy to maintain or increase the proportion of active forms of commuting through adulthood.

Analyses of gender differences indicated a higher variation in women in terms of AC in low and high walkability areas. One reasonable explanation could be lower perceived safety for women in low walkability areas, which discourages women from using AC options in low walkability areas (Leslie et al., 2010).

Possible practical implications should positively influence public health approaches through AC (especially in terms of bicycle travel to school or work) among the inhabitants of Liberec city. There is a need to improve the cycling network. It would be beneficial to implement more interventions (such as the "Bike to work" program by the AUTO*MAT association) for the public to encourage active and to discourage passive forms of commuting. Other options include providing accessible recreational facilities on the routes to school or work and improving the infrastructure and safety of disadvantages localities.

Strengths and limitations

One strength of this study is the large sample (23,621 respondents), which is approximately 25% of the permanent inhabitants of Liberec city. Another strength is the objective assessment of environmental attributes using GIS.

However, we must mention the limitations related to our study. Research in the fields of PA, AC and public health uses a socio-ecological model but only focuses one-directionally on different levels of possible determinants. The depth of the socio-ecological model, however, offers a more dualistic theoretical understanding of the associations (Sallis, Owen, & Fisher, 2008). Another limitation is that the participants were only economically active inhabitants or students (individuals older than 6 years including working seniors). Thus, this is a subsection of the normal population structure. This study does not include the population of preschool children, non-working adults and retired seniors. An additional limitation is the use of a self-report survey to assess AC. The conclusions of this study must be, with respect to the subjective answers to the questions asked, presented with certain care and cannot be generalized.

Conclusions

The built environment influences AC to school or work in Liberec city. In high walkability areas, the proportion of active commuters is significantly higher (20.32%) compared with that of low walkability areas (12.54%). Most of the inhabitants walk (among those who selected only AC as a means of commuting), and a very low number of individuals use a bicycle as a means of commuting. Future studies should also focus

on a comparison among various characteristics of AC (e.g., duration and distance) in various cities across the Czech Republic or abroad and should search for factors (e.g., socioeconomic status and demography) that can positively or negatively influence AC in local areas.

Acknowledgment

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