Accessibility and availability of physical activity infrastructure in Lisbon

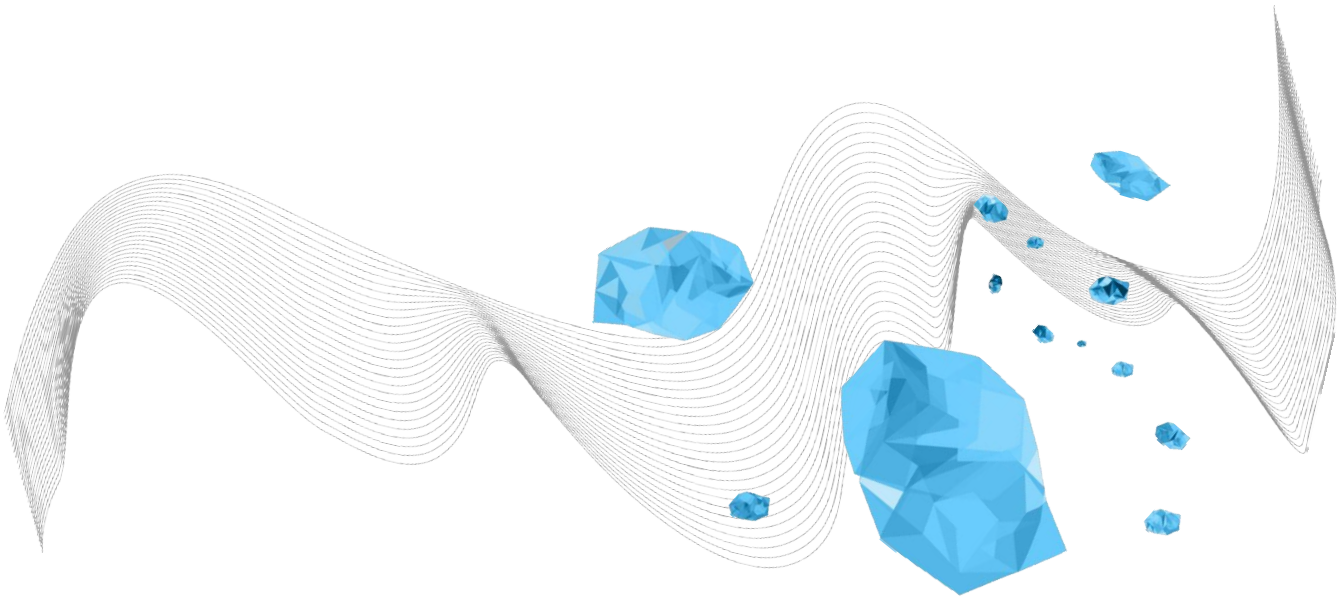
Author

Andrew Erasmus
BSc Health Sciences
Faculty of Science and Technology
University of Twente

Supervisors

1st supervisor: prof.dr. Justine Blanford
2nd supervisor: dr. Nienke Beerlage - de Jong

Date: 28 June 2023



UNIVERSITY OF TWENTE.

Abstract

Introduction: Insufficient physical activity is a worldwide public health problem, and environmental factors can have an influence. This paper studied the availability and accessibility of physical activity facilities in the Lisbon Metropolitan Area. The focus lies on Lisbon because of its high level of physical inactivity compared to other countries within the European Union, with 57% of residents being physically inactive. This study aimed to see if the availability and accessibility of physical activity facilities could influence the activity levels of the residents.

Method: Geospatial data from OpenStreetMap were used in ArcGIS Pro and Excel to analyse the availability and accessibility of the facilities. A statistical and geospatial analysis was conducted to count and measure the available facilities and their distance from residential areas. The analysed facilities were bicycle rentals, sports centres, swimming pools, and parks. These facilities were chosen since residents would use them for physical activity, according to literature.

Results: The analysis showed that most facilities are located in the Lisbon centre, with 52.9% of the facilities, such as bicycle rentals, sports centres, and swimming pools, having a 1000 m distance from residential areas and 37.4% of residents living more than 300 m away from parks.

Conclusion: This study concludes that having fewer facilities or having facilities at greater distances from residential areas could affect residents' physical activity levels. However, more research is needed to find a correlation between low levels of physical inactivity and the availability and accessibility of facilities.

Keywords: Physical activity, availability, accessibility, Lisbon Metropolitan Area

Table of Contents

Introduction

Physical inactivity is a worldwide public health problem. Globally, one in four adults and more than three-quarters of adolescents are physically inactive [1, 2]. Physical inactivity increases the risk of non-communicable diseases such as cardiovascular diseases, diabetes, and cognitive decline. It also leads to an increased risk of certain cancers, such as breast, lung, and colorectal cancer [1, 3, 4]. Furthermore, being physically inactive can contribute to weight gain and obesity [5]. Therefore, it is vital for people to be physically active to reduce the risk of chronic diseases and all-cause mortality. Physical activity (PA) is defined by the World Health Organization (WHO) as "any bodily movement produced by skeletal muscles that requires energy expenditure" [6]. Moreover, physical inactivity is defined by the WHO as insufficient PA that does not meet the recommended WHO guidelines of physical activity and sedentary behaviour [6]. Therefore, to prevent the effects of physical inactivity, the WHO recommends that adults be physically active for 150–300 minutes per week of moderate intensity or 75–100 minutes of vigorous intensity. In addition, adults should undertake muscle-strengthening activities at least twice a week. Lastly, since physical inactivity increases the risk of non-communicable diseases in the population, this also increases the burden and costs of healthcare [7, 8].

Portugal, a European Union (EU) country, has one of Europe's highest percentages of physical inactivity and sedentary lifestyles. According to the WHO, 60% of men and 70% of women in Portugal are not meeting the recommended PA guidelines [9]. Moreover, according to the latest data from the WHO, 84.3% of Portuguese adolescents between the ages of 11 and 17 are physically inactive. 78.1% of male and 90.7% of female adolescents did not meet the recommended PA guidelines in Portugal in 2016 [10]. Therefore, a national plan was introduced in 2016 to increase PA rates [9]. The plan aimed to improve overall knowledge and awareness about physical activity, foster a stronger belief in its benefits, encourage more people to participate in physical activity, and equip health professionals with the necessary knowledge and tools. In addition, the national plan encourages changes to the physical environment that facilitate physical activity, create environments that promote physical activity, monitor physical activity, and identify best practices [9]. Despite this, the prevalence of PA in Portugal is still low. For example, according to Louro et al., circa 57% of families living in the Lisbon Metropolitan Area are physically inactive [11]. This percentage is above the national expectation of the national plan [9, 11]. Additionally, Lisbon has a high mortality rate of diabetes [12], with overweight and obesity becoming a public health concern [13]. Therefore, one must examine the factors influencing PA to understand why residents are physically inactive.

Several known factors, such as individual and environmental factors, influence the PA level. Individual factors are, for example, genetics, motivation, and beliefs about participating in PA. Environmental factors can be seen as the environment's infrastructure where individuals reside, including the neighbourhood's walkability, public transport, health/ sporting facilities, and green areas [14]. According to Tcymbal et al., improving the infrastructure, for example, by creating more parks, can promote an increase in PA [15]. However, Louro et al. argue that it is also vital to know the specific infrastructure locations [11]. In the context of this article, knowing the location and accessibility of the facilities, green space, or park is crucial. This would give an image of what is accessible at a certain distance for an individual in the Lisbon Metropolitan Area. Accessibility in this context is seen as the potential for an individual to reach opportunities [16, 17], such as parks and other facilities, where they can practice or participate in PA. This is because research shows that if an individual resides in an area with various facilities promoting PA, it increases the PA level and promotes a healthier lifestyle [18]. Furthermore, several studies also recognised the importance of increasing PA levels in communities to create healthy communities [19-21]. However, for this to occur, there would need to be a change in the environment and urban design [15].

On the contrary, fewer facilities at a greater distance would reduce the number of individuals to be physically active [22]. This is also true for open and green spaces [23]. For example, a study by Toftager et al. concluded that residents who live in 300 m proximity to a park or green space reported that an important reason for them to go to a park is for exercise or recreational activities. However, those who live more than 1 km from a green area or park reported that they do not see PA as a fundamental reason to visit a park [24]. Thus, understanding where and when people are physically active or inactive is crucial. This leads to a more specific view of where changes must occur to promote PA [25]. The studies mentioned provide insights into what is vital to accessibility [23, 24]. Therefore, if the distance to a facility or infrastructure is short, the individual is more likely to use it for PA. For example, according to Louro et al., families who live further away from Lisbon city centre were 5 to 8% more active than families who reside in the centre and the ones who live close to the centre [11]. The difference in activity level was clarified, with the families living further away from the centre having more access to green areas and forest spaces. This encourages families to pursue outdoor activities such as hiking and cycling [11]. However, there is also a need to know if any individual factors are influencing the residents not to be active.

In a study by Guedes-Estevez et al. [26], who researched individual factors of PA in the Portuguese population, they concluded that the population had sufficient knowledge and awareness about the benefits of PA. However, some groups lacking PA resources saw it as a barrier to participate in PA. The authors also suggested increasing environmental green areas to promote PA [26]. Louro et al. also concluded that less urbanised areas in the Lisbon Metropolitan Area with more access to green spaces increased the PA level of residents [11]. Therefore, a more in-depth look at the availability and accessibility of the Lisbon Metropolitan Area infrastructure is needed to understand if a lack of access to facilities contributes to the low PA levels. As a result, the main question is: What types of physical activity or green facilities and infrastructure are currently available in the Lisbon Metropolitan Area, and how accessible are they to the residents?

The sub-questions to help answer the research question are:

- What physical activity facilities are available in the Lisbon Metropolitan Area?
- How accessible are the available physical activity facilities to the residents?
- How could the accessibility of physical activity facilities contribute to the physical activity level of the residents in Lisbon?

Method

Study design

This paper is meant to study what type of infrastructure is available and accessible to residents living in the Lisbon Metropolitan Area. Therefore, the design of this study can be seen as observational since the availability of infrastructure was researched at a specific time.

Setting

This study focused on the Lisbon Metropolitan Area. However, as the Lisbon Metropolitan Area consists of 18 municipalities, this poses the risk of being too broad to analyse. Since the highest rates of physical inactivity are more prevalent in the city centre and regions close to the city centre, a ring system classification was used. This ring system classification from Louro et al. classified the centre as the beginning and the 15 km distance from the centre as the first ring, which can be seen in Figure 1 [11]. Due to the high physical inactivity rate in the city centre and the first ring, only these two regions were analysed in this paper. To see a close-up of the analysed regions, look at Figure 2 in Appendix A.

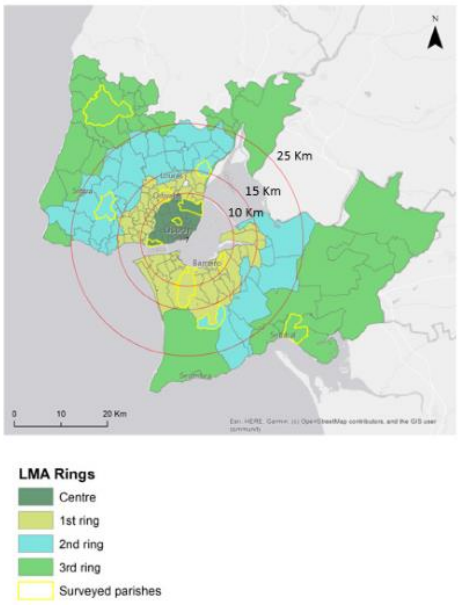


Figure 1. The ring system classification of Louro et al. [11] captures the allocation of the different municipalities in the Lisbon Metropolitan Area.

Materials

Open data were gathered from OpenStreetMap (OSM) to analyse the spatial data of Lisbon. The data from OSM were downloaded in 2023, and Table 1 shows the data source. The downloaded data sets for Lisbon included points of interest (POI), land use, and residential areas. Furthermore, ArcGIS Pro version 3.1.0 and Microsoft 365 Excel version 2303 were used to analyse the data. ArcGIS is a geographic information system (GIS) software that can analyse and visualise (geospatial) data [27].

Table 1. Data source

Source	Year	URL
OpenStreetMap	2023	https://download.geofabrik.de/europe/portugal.html

Data Analysis

Points of Interest

To analyse the first sub-question, "what physical activity facilities are available in the Lisbon Metropolitan Area?" The POI data from OSM were uploaded to ArcGIS on a topographic map of Lisbon. To simplify the analysis of the POI, since it has all known available facilities in Lisbon only four specific types of facilities were selected from the data: sports centres, swimming pools, parks, and bicycle rentals. These facilities were chosen since Louro et al. stated that these are the facilities residents would use to practice PA in the Lisbon Metropolitan Area [11]. These four facilities were selected from the POI data set, placed into a separate data set, and uploaded to the map. A statistical summary was conducted to count and quantify each type of facility. Afterwards, to count each facility's total individually in the centre and metropolitan area, the facilities were selected separately by their locations and exported to Excel. Using the COUNTIF formula, the total of each type of facility was calculated. A Kernel Density Estimate was used to create a surface area that highlighted the density of where most facilities are located. Finally, a table of the facilities and a map of the Kernel Density were made in ArcGIS to visualise the data.

Land use

The land use and residential data from OSM were uploaded in ArcGIS to analyse the parks, green areas, and residential areas. As for the POI, a separate data set was made to simplify the analysis, with only parks and nature reserves from the land use data set. Furthermore, for clarity, this paper uses nature reserves and green areas interchangeably, and green facilities refer to parks and nature reserves. The data set containing only the green facilities was uploaded on the map next to the residential data. Afterwards, a statistical summary was conducted to count the available green facilities and residential areas. Moreover, the total surface area of the green facilities and residential areas was calculated by converting the data from polygon to raster. After the data were converted to raster, a Summarise Within analysis was conducted. The Summarise Within analysis summarised tables of the square area of the green facilities and residential area. Afterwards, the tables were exported to Excel, and the SUMIF formula was used to calculate the total square area of the green facilities and the SUM formula for the residential areas. To further count the available green facilities between the centre and metropolitan area, the green facilities close to the centre and metropolitan area were selected separately in ArcGIS and exported and counted in Excel with the COUNTIF formula. Lastly, a cartographic map was made in ArcGIS of Lisbon's green facilities and residential areas to visualise the data. Finally, a table was made with the total square area of the green facilities and residential areas.

Accessibility

Lastly, to analyse the accessibility of the facilities, a Multiple-Ring Buffer analysis was conducted to calculate the distance between the facilities and residential areas. The facility data and residential data were uploaded to the map. The raster data of the residential areas were used to calculate the distance accurately. Four distances were chosen when calculating the Multiple-Ring Buffer. These distance areas were 100, 300, 500, and 1000 m. These were chosen since individuals can walk to a facility within these distances [28]. After applying the Multiple-Ring Buffer to the facilities, a Zonal Statistics analysis was conducted to calculate the total distances of the facilities in each distance area to residential areas. Afterwards, the percentage of facilities in each distance area was calculated. For the accessibility analysis between the green facilities and residential areas, a Near Tool Table analysis was conducted. After the analysis, the table was exported to Excel. First, the distances with a value of 0 were removed from the Excel table since 0 m between a green facility and a residential area is not possible, and distances greater than and equal to 0.50 m were kept. Next, the COUNTIF formula was used in Excel to calculate the total distance of residential areas within less than 300 m. The same formula was used for distances greater than 1000 m in residential areas. Furthermore, the COUNTIFS formula calculated the residential distance as greater than or equal to 300 m but less than 1000 m. When analysing the distances of the facilities, this could give an idea of how accessibility can contribute to the PA level of

the residents. Afterwards, the percentage of each distance was calculated and put into a table. Finally, to calculate the minimum, maximum, and average distance between the green facilities and residential areas, the MIN, MAX, and AVERAGE formulas were used in Excel.

Results

Availability of facilities

As a first step, the availability of the facilities was calculated. Table 2 shows the quantity of each facility, with bicycle rental being the most common facility (n = 161) and park the least (n = 8) from the POI data. Figure 3 shows the Kernel Density Estimate of the facilities in the Lisbon centre. As shown in Figure 3, the highest density of facilities is located in the centre of Lisbon. In addition, these data show that most of the PA facilities are located in and around the Lisbon city centre compared to the metropolitan area, with bicycle rental being the facility with the most quantity (n = 160) in the city centre. To further see all the available facilities in the Lisbon Metropolitan Area on a map, see Figure 4 in Appendix B. Figure 3 was used since the Kernel Density Estimate was only concentrated and visible in the Lisbon centre, not the surrounding area.

Table 2. Quantity of the available facilities in the Lisbon centre and metropolitan Area.

Facilities	Quantity of facilities in the Lisbon centre	Quantity of facilities in the Lisbon Metropolitan Area	Total
Bicycle rental	160	1	161
Sports centre	27	21	48
Swimming pool	6	4	10
Park	1	7	8

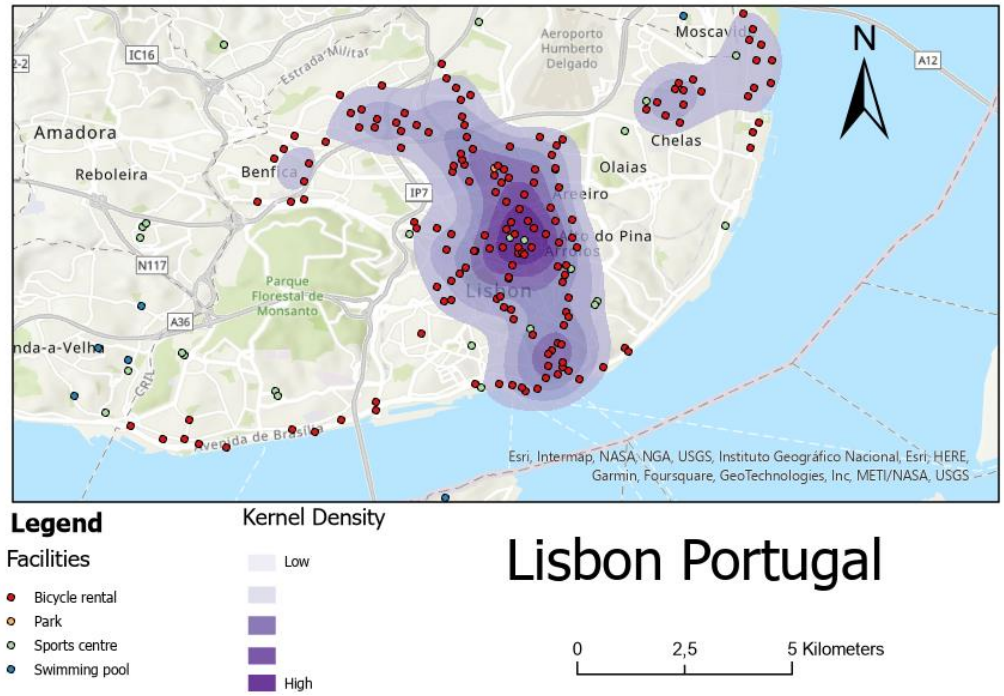


Figure 3. The Kernel Density Estimate of the available facilities in the Lisbon centre.

When looking at land use in the Lisbon Metropolitan Area, Table 3 shows that the most common green facilities are parks (n = 829) compared to nature reserves (n = 36). Furthermore, parks are more commonly located in the city centre than the metropolitan area, with the metropolitan area having fewer green facilities than the centre. This can be seen in Table 4. Moreover, with parks being the most common green facility, they have a smaller total area of 13.6 km^2 compared to nature reserves, which have a total area of 46.8 km^2 (Table 3). Lastly, a map of Lisbon's green facilities and residential areas and where the green facilities are located can be seen in Figures 5.1 and 5.2. Figure 5.1 shows that most parks (n = 528) are located in and around the city centre, compared to Figure 5.2, which shows the Lisbon Metropolitan Area with fewer parks (n = 301). This shows that parks and nature reserves are less prevalent in the metropolitan area compared to the centre of Lisbon.

Table 3. Total quantity and total square area of the green facilities and residential areas in the Lisbon Metropolitan Area.

Green facilities and residential area	Quantity	Total area (km^2)
Park	829	13.6
Nature reserve	36	46.8
Residential area	12530	90.35

Table 4. Quantity of the green facilities in the Lisbon centre and Lisbon Metropolitan Area.

	Park (n)	Nature reserve (n)
Lisbon centre	528	17
Lisbon Metropolitan Area	301	19

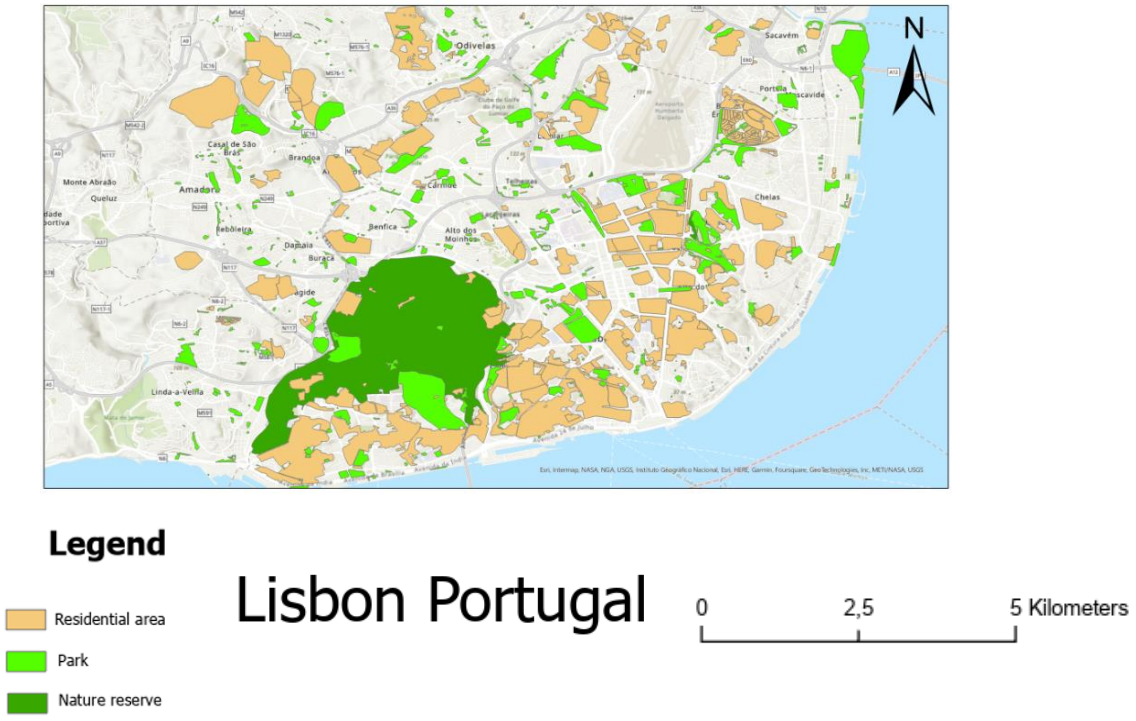


Figure 5.1. The green facilities and residential areas in the Lisbon centre.

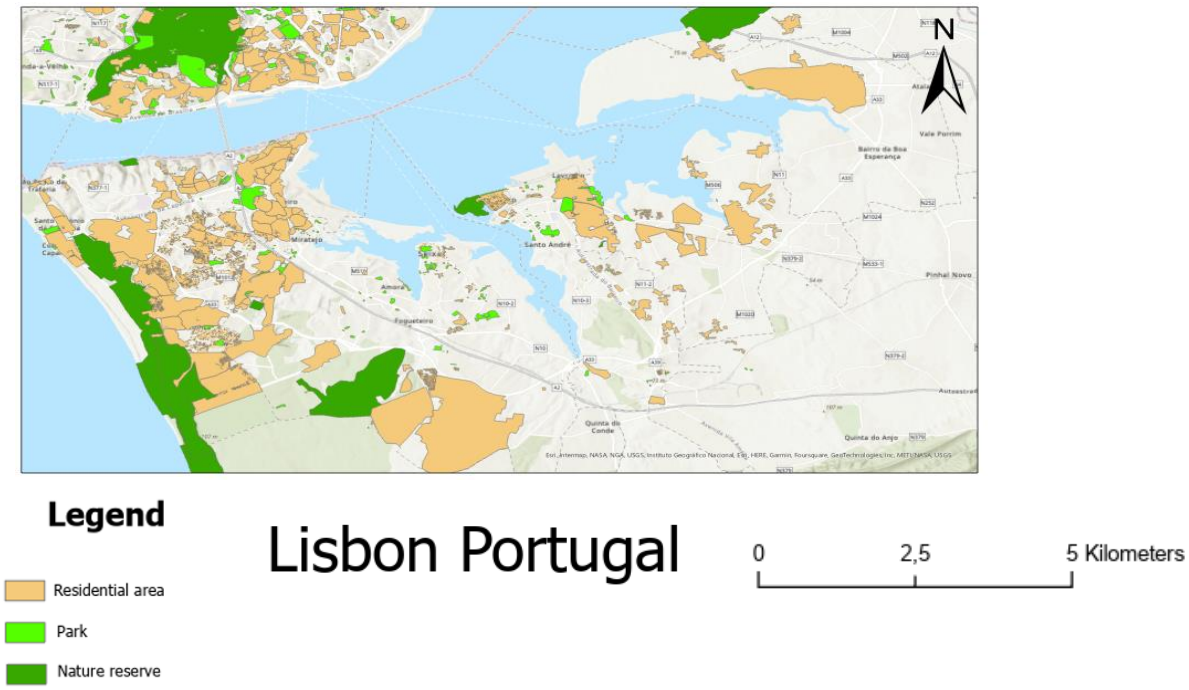


Figure 5.2. The green facilities and residential areas in the Lisbon Metropolitan Area.

Accessibility of facilities

When analysing the accessibility of the facilities, it turned out that 52.9% of the residential areas are located at a distance of 1000 m from the facilities. In comparison, only 3.8% of the facilities are located at a distance of 100 m from residential areas, as seen in Table 5. This data show that most residents live 1000 m away from the facilities. Furthermore, for the accessibility between residential areas and green facilities, 62.5% of residential areas are located less than 300 m away from a green facility. On the other hand, only 0.16% of residential areas are located at a distance greater than 1000 m, as seen in Table 6. This then suggests that most residents are located close to a green facility. Finally, the average distance between residential areas and green facilities is 272 m, with a minimum distance of 0.50 m and a maximum distance of 2210 m.

Table 5. Distances of the facilities to residential areas.

Distance (m)	Facilities (n = 3559)	Percentage
100	134	3.8
300	769	21.6
500	772	21.7
1000	1884	52.9

Table 6. Distances from the residential areas to the green facilities.

Distance (m)	Residential area (n = 12260)	Percentage
<300	7657	62.5
≥300 <1000	4583	37.4
≥1000	20	0.16

The results show that most facilities are located in and around the Lisbon city centre rather than in the surrounding metropolitan area. Furthermore, the results also show that 37.4% of the residential area are located more than 300 m away from the green facilities, and 52.9% of facilities, such as sports centres, swimming pools, and bicycle rentals, are located at a 1000 m away from residential areas.

Discussion

This study reveals that most PA facilities, such as bicycle rentals, sports centres, swimming pools, and parks, are available in the Lisbon Metropolitan Area. Most of these facilities are located in or nearby the Lisbon city centre, with bicycle rentals being the facility with the highest availability. Furthermore, most of the facilities, except for parks, are located at a distance of 1000 m from residential areas. This can lead to a low contribution for residents to use them to participate in PA. Moreover, for green facilities, parks are more common in the centre of Lisbon than in the surrounding metropolitan area. Lastly, with parks being more common in the centre, there is also a high percentage of residential areas located near a green facility.

Relevant findings

One interesting finding from this study was that bicycle rentals are the most common PA facilities in the Lisbon centre, as there is only one bicycle rental outside the city centre or in the studied metropolitan area. This finding is intriguing since Lisbon is still considered a starter cycling city and has some political and social resistance towards cycling. However, due to the COVID-19 pandemic, bicycle rentals became more prevalent in Lisbon since residents were worried about using public transport during the pandemic. Furthermore, the introduction of bicycle rentals is also meant to encourage residents and tourists to be more active [29]. However, since it was recently introduced right before the pandemic, there is insufficient information about its usage among residents and tourists. This also leads to the fact that bicycle rentals were used mainly by residents for commuting reasons and secondarily for exercise purposes during the pandemic. Nevertheless, Teixeira et al. concluded that there was an increase in cycling, especially in the female population in Lisbon [29]. However, since the pandemic has ended, there has yet to be a definitive answer as to whether the residents will keep cycling for PA purposes.

A second interesting finding relates to the first, since bicycle rentals and other facilities were most common in the Lisbon centre. This could be seen as inequality for people to reach or use those PA facilities. Moreover, having more facilities or facilities with the most availability may not affect residents' ability to be active. For example, most bicycle or (sports) facilities are usually made for young white males. This can limit the use of people of different genders and sizes [29, 30]. Additionally, people with (physical) disabilities or visual impairments cannot always access and use PA facilities without issues [31, 32]. Therefore, the green facilities, sports centres, and swimming pools have a chance of not being accessible to every resident. This can also hinder the individual and influence a family to participate in PA together. However, other facilities, such as public fitness equipment or open gyms [33, 34], are becoming more common in the Lisbon Metropolitan Area. See Figure 6 in Appendix C for an example of fitness equipment in a public park. Nonetheless, it is difficult to analyse the availability and accessibility since no data is currently available in OSM.

A third interesting finding was that 62.5% of the residential areas are located less than 300 m from a green facility. This challenges the notion that residents' proximity to a green facility does not equal constant use for PA. There might be different factors that are of influence. However, according to Nielsen et al., residents have a steep decline in using parks or recreational facilities when the facilities are at a distance of approximately 300 m and above [35]. Therefore, 37.4% of residents who live more than 300 m from a green facility might not use or frequent a green facility. Additionally, a percentage of the 62.5% who live near 300 m might also not frequent a green facility. Furthermore, they might also use public transport or an automobile to get to a green facility, reducing their PA level [36].

Strengths & Limitations

A major strength of this paper is that it builds upon existing studies about PA facilities and PA levels in the Lisbon Metropolitan Area. It adds data on the accessibility and availability of PA facilities in Lisbon's centre and metropolitan area. Nonetheless, this study also has limitations. The first limitation concerns the possibility that some data from OSM might be missing or incomplete. This is seen as the POI data set only recognised 8 parks when being analysed, but when analysing the land use data set, 829 parks were recognised. This makes data interpretation not entirely accurate since the data sets are incomplete or the data is also in another form, for example, points or polygons. To minimise this, land use data were used to look at the green facilities specifically, and data sets from OSM with the most complete data were used. The second limitation concerns the accessibility and expense of the facilities. This paper did not look at the real-life situation of residents commuting to a facility or the price of using the facilities. For example, roads or sidewalks might not be pedestrian or bicycle friendly (see Figures 7 and 8 in Appendix D), and the facilities, such as bicycle rentals, sports centres, or swimming pools, might be too costly for residents. The last limitation concerns the activity level of residents, since this paper only looked at the availability and accessibility of facilities in the Lisbon Metropolitan Area and not how active the residents are when using the facilities. For example, when visiting a sports centre or swimming pool, an individual might practice light, moderate, or vigorous PA, which is not possible to analyse with spatial data. The same can be said for green facilities, as people might visit a park only to sit or have a picnic.

Practical implication

This study's findings suggest that having few PA and green facilities in a metropolitan area could contribute to low PA levels among residents. Therefore, it is crucial, for example, for policymakers to look at where changes can occur in areas with few PA facilities to increase PA levels among residents.

Future research

It is crucial to look at all the available PA facilities and infrastructure in an area for future studies. For example, Ana Louro, a researcher in Lisbon, gave information through personal communication that they are seeing a rise in fitness equipment around the metropolitan area to encourage residents to be active. Thus, more types of PA facilities are being made for residents. In addition, a future study could examine why some facilities are distributed only in certain areas, such as bicycle rentals in the city centre. A final idea for a future study is to survey and ask residents what type of PA facility they want in their vicinity and why. This can create an image of what PA facilities residents want to use to stay physically active.

Conclusion

As physical inactivity is a global public health problem, it is essential to understand what factors are causing the inactivity levels in a country. Therefore, this paper studied the availability and accessibility of PA facilities in the Lisbon Metropolitan Area to see if these factors could influence the residents to be physically inactive. This study found that 52.9% of the PA facilities are located at a distance of 1000 m from residential areas in Lisbon, and most of the green facilities are located in the city centre compared to the metropolitan area. As a result, the lack of facilities around the metropolitan area and the great distance to facilities could contribute to the low PA levels of Lisbon's residents. Therefore, it is crucial for further studies to research the correlation between the accessibility and availability of PA facilities and PA levels among residents.

Reference List

1. Guthold R, Stevens GA, Riley LM, Bull FC. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1.9 million participants. Lancet Glob Health. 2018;6(10):e1077-e86. doi: 10.1016/S2214-109X(18)30357-7.
2. Guthold R, Stevens GA, Riley LM, Bull FC. Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys with 1.6 million participants. Lancet Child Adolesc Health. 2020;4(1):23-35. doi: 10.1016/S2352-4642(19)30323-2.
3. Patterson R, McNamara E, Tainio M, de Sa TH, Smith AD, Sharp SJ, et al. Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis. Eur J Epidemiol. 2018;33(9):811-29. doi: 10.1007/s10654-018-0380-1.
4. Cao Z, Xu C, Zhang P, Wang Y. Associations of sedentary time and physical activity with adverse health conditions: Outcome-wide analyses using isotemporal substitution model. EClinicalMedicine. 2022;48:101424. doi: 10.1016/j.eclinm.2022.101424.
5. Haskell WL, Blair SN, Hill JO. Physical activity: health outcomes and importance for public health policy. Prev Med. 2009;49(4):280-2. doi: 10.1016/j.ypmed.2009.05.002.
6. Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. Br J Sports Med. 2020;54(24):1451-62. doi: 10.1136/bjsports-2020-102955.
7. Santos AC, Willumsen J, Meheus F, Ilbawi A, Bull FC. The cost of inaction on physical inactivity to public health-care systems: a population-attributable fraction analysis. Lancet Glob Health. 2023;11(1):e32-e9. doi: 10.1016/S2214-109X(22)00464-8.
8. Mattli R, Wieser S, Probst-Hensch N, Schmidt-Trucksass A, Schwenkglenks M. Physical inactivity caused economic burden depends on regional cultural differences. Scand J Med Sci Sports. 2019;29(1):95-104. doi: 10.1111/sms.13311.
9. Shinn C, Salgado R, Rodrigues D. National Programme for Promotion of Physical Activity: the situation in Portugal. Cien Saude Colet. 2020;25(4):1339-48. doi: 10.1590/1413-81232020254.26462019.
10. World Health Organization: The Global Health Observatory: Prevalence of insufficient physical activity among school going adolescents aged 11-17 years. https://www.who.int/data/gho/data/indicators/indicator-details/GHO/prevalence-of-insufficient-physical-activity-among-school-going-adolescents-aged-11-17-years (2023). Accessed 25 February 2023.
11. Louro A, Franco P, Marques da Costa E. Determinants of Physical Activity Practices in Metropolitan Context: The Case of Lisbon Metropolitan Area, Portugal. Sustainability. 2021;13(18):10104. doi: 10.3390/su131810104.
12. Lustigova M, Dzurova D, Costa C, Santana P. Health Disparities in Czechia and Portugal at Country and Municipality Levels. Int J Environ Res Public Health. 2019;16(7):1139. doi: 10.3390/ijerph16071139.
13. OECD/ European Observatory on Health Systems and Policies. Portugal: Country Health Profile 2021. State of Health in the EU. Paris/European Observatory on Health Systems and Policies, Brussels: OECD Publishing; 2021.
14. Bauman AE, Reis RS, Sallis JF, Wells JC, Loos RJ, Martin BW, et al. Correlates of physical activity: why are some people physically active and others not? Lancet. 2012;380(9838):258-71. doi: 10.1016/S0140-6736(12)60735-1.
15. Tcymbal A, Demetriou Y, Kelso A, Wolbring L, Wunsch K, Wasche H, et al. Effects of the built environment on physical activity: a systematic review of longitudinal studies taking sex/gender into account. Environ Health Prev Med. 2020;25(1):75. doi: 10.1186/s12199-020-00915-z.
16. Boisjoly G, El-Geneidy A. Daily fluctuations in transit and job availability: A comparative assessment of time-sensitive accessibility measures. Journal of Transport Geography. 2016;52:73-81. doi: 10.1016/j.jtrangeo.2016.03.004.
17. Preston J, Raje F. Accessibility, mobility and transport-related social exclusion. Journal of Transport Geography. 2007;15(3):151-60. doi: 10.1016/j.jtrangeo.2006.05.002.

18. Cohen DA, Han B, Derose KP, Williamson S, Marsh T, Raaen L, et al. Promoting physical activity in high-poverty neighborhood parks: A cluster randomized controlled trial. Soc Sci Med. 2017;186:130-8. doi: 10.1016/j.socscimed.2017.06.001.
19. Santos T, Ramalhete F, Juliao RP, Soares NP. Sustainable living neighbourhoods: Measuring public space quality and walking environment in Lisbon. Geography and Sustainability. 2022;3(4):289-98. doi: 10.1016/j.geosus.2022.09.002.
20. Casino F, Patsakis C, Batista E, Borras F, Martinez-Balleste A. Healthy Routes in the Smart City A Context-Aware Mobile Recommender. Ieee Software. 2017;34(6):42-7. doi: 10.1109/Ms.2017.4121209.
21. Lowe M, Adlakha D, Sallis JF, Salvo D, Cerin E, Moudon AV, et al. City planning policies to support health and sustainability: an international comparison of policy indicators for 25 cities. Lancet Glob Health. 2022;10(6):e882-e94. doi: 10.1016/S2214-109X(22)00069-9.
22. Greer AE, Castrogivanni B, Marcello R. Park Use and Physical Activity Among Mostly Low-to-Middle Income, Minority Parents and Their Children. J Phys Act Health. 2017;14(2):83-7. doi: 10.1123/jpah.2016-0310.
23. Gintoli I, Bellisario V, Squillacioti G, Caputo M, Borraccino A, Dalmasso P, et al. Urbanization and greenness in HBSC survey: Association with life satisfaction and health complaints. European Journal of Public Health. 2020;30(Supplement_5):ckaa166. 099. doi: 10.1093/eurpub/ckaa166.099.
24. Toftager M, Ekholm O, Schipperijn J, Stigsdotter U, Bentsen P, Gronbaek M, et al. Distance to green space and physical activity: a Danish national representative survey. J Phys Act Health. 2011;8(6):741-9. doi: 10.1123/jpah.8.6.741.
25. Kelso A, Reimers AK, Abu-Omar K, Wunsch K, Niessner C, Wasche H, et al. Locations of Physical Activity: Where Are Children, Adolescents, and Adults Physically Active? A Systematic Review. Int J Environ Res Public Health. 2021;18(3). doi: 10.3390/ijerph18031240.
26. Guedes-Estevez E, Costa AR, Moura-Ferreira P, Lunet N, Morais S. Regular physical activity-related awareness and knowledge in Portugal: results from a population-based survey. Porto Biomed J. 2021;6(2):e130. doi: 10.1097/j.pbj.0000000000000130.
27. Fleming J, Marvel SW, Supak S, Motsinger-Reif AA, Reif DM. ToxPi*GIS Toolkit: creating, viewing, and sharing integrative visualizations for geospatial data using ArcGIS. J Expo Sci Environ Epidemiol. 2022;32(6):900-7. doi: 10.1038/s41370-022-00433-w.
28. Gidlow C, Cerin E, Sugiyama T, Adams MA, Mitas J, Akram M, et al. Objectively measured access to recreational destinations and leisure-time physical activity: Associations and demographic moderators in a six-country study. Health Place. 2019;59:102196. doi: 10.1016/j.healthplace.2019.102196.
29. Teixeira JF, Cunha I. The effects of COVID-19 on female and male bike sharing users: Insights from Lisbon's GIRA. Cities. 2023;132:104058. doi: 10.1016/j.cities.2022.104058.
30. Hirsch JA, Stewart I, Ziegler S, Richter B, Mooney SJ. Residents in Seattle, WA Report Differential Use of Free-Floating Bikeshare by Age, Gender, Race, and Location. Frontiers in Built Environment. 2019;5:17. doi: 10.3389/fbuil.2019.00017.
31. Powrie B, Kolehmainen N, Turpin M, Ziviani J, Copley J. The meaning of leisure for children and young people with physical disabilities: a systematic evidence synthesis. Dev Med Child Neurol. 2015;57(11):993-1010. doi: 10.1111/dmcn.12788.
32. Alcaraz-Rodriguez V, Medina-Rebollo D, Munoz-Llerena A, Fernandez-Gavira J. Influence of Physical Activity and Sport on the Inclusion of People with Visual Impairment: A Systematic Review. Int J Environ Res Public Health. 2021;19(1):443. doi: 10.3390/ijerph19010443.
33. Chow HW. Outdoor fitness equipment in parks: a qualitative study from older adults' perceptions. BMC Public Health. 2013;13:1216. doi: 10.1186/1471-2458-13-1216.
34. Lee JLC, Lo TLT, Ho RTH. Understanding Outdoor Gyms in Public Open Spaces: A Systematic Review and Integrative Synthesis of Qualitative and Quantitative Evidence. Int J Environ Res Public Health. 2018;15(4):590. doi: 10.3390/ijerph15040590.
35. Nielsen TS, Hansen KB. Do green areas affect health? Results from a Danish survey on the use of green areas and health indicators. Health Place. 2007;13(4):839-50. doi: 10.1016/j.healthplace.2007.02.001.

36. Félix R, Moura F, Clifton KJ. Maturing urban cycling: Comparing barriers and motivators to bicycle of cyclists and non-cyclists in Lisbon, Portugal. Journal of Transport & Health. 2019;15:100628. doi: 10.1016/j.jth.2019.100628.

Appendix A

Figure 2. The rings represent the regions that were analysed in this paper.

Appendix B

Figure 4. Map of the facilities in the Lisbon Metropolitan Area.

Appendix C

Figure 6. Fitness equipment in a public park in Lisbon. Picture is from Google Open Street Map taken by Rowena Rowley in 2022.

Appendix D

Figure 7. Different locations in Lisbon showing narrow streets and sideways. Pictures are taken from Santos et al. [19].

Figure 8. A person trying to rent a bicycle in the Lisbon city centre. Picture is taken from Google Open Street Map.