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Public transport and walking in commuting in São Paulo during the COVID-19 pandemic

Transporte público e caminhada no deslocamento em São Paulo durante a pandemia de Covid-19

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ABSTRACT

Objective: Describe urban mobility during the COVID-19 pandemic among adults in São Paulo and to analyze the association between the use of public transportation and walking as a mode of commuting. Methods: The study was conducted in São Paulo, Brazil. This is a cross-sectional study using data from the second wave of the Health Survey (ISA) on Physical Activity and Environment, collected through telephone interviews between October 2020 and February 2021, with 1,434 adults. Urban mobility for work was assessed through questions regarding exposure to the home office model, commuting time to work, and the primary mode of transportation used. Walking as a mode of commuting was measured using the long version of the International Physical Activity Questionnaire. Descriptive statistics and Poisson regression were performed to examine the association between the use of public transportation and walking. The models were adjusted for sex, age, education level, presence of public transportation stations, and residential region according to the health coordination department. Results: The main findings indicate that, among workers interviewed during the COVID-19 pandemic, the majority worked in-person and primarily used public transportation for commuting. Furthermore, a statistically significant association was found between being a public transportation user and walking as a mode of commuting, both in the crude and adjusted models. Conclusion: During the COVID-19 pandemic, the use of public transportation was associated with walking for commuting among adults.

Keywords: Urban mobility; Walking; Physical activity; Commuting.

RESUMO

Objetivo: Descrever a mobilidade urbana durante a pandemia de Covid-19 entre adultos de São Paulo e analisar a associação entre o uso de transportes públicos e a caminhada como forma de deslocamento. Método: O estudo foi realizado em São Paulo, Brasil. Trata-se de um estudo transversal com dados da segunda onda do Inquérito de Saúde (ISA) – Atividade Física e Ambiente, coletados por entrevistas telefônicas entre outubro de 2020 e fevereiro de 2021, com 1.434 adultos. A mobilidade urbana para o trabalho foi avaliada por questões sobre exposição ao modelo home office, tempo de deslocamento para o trabalho e principal meio de transporte utilizado. A caminhada como forma de deslocamento foi medida pelo International Physical Activity Questionnaire, versão longa. Foram realizadas estatísticas descritivas e regressão de Poisson para verificar a associação entre uso de transporte coletivo e caminhada. Os modelos foram ajustados para sexo, idade, escolaridade, presença de estações de transporte coletivo e região de residência segundo a coordenadoria de saúde. Resultado: Os principais resultados mostram que, entre os trabalhadores entrevistados durante a pandemia de Covid-19, a maioria atuava de forma presencial e usava principalmente transportes públicos coletivos para se deslocar. Além disso, foi encontrada associação entre o uso de transporte público e caminhada no deslocamento, tanto para o modelo bruto quanto ajustado. Conclusão: Durante a pandemia de Covid-19 o uso de transportes públicos foi associado com a caminhada de deslocamento entre adultos.

Palavras-chave: *Mobilidade urbana; Caminhada; Atividade física; Deslocamento.*

Introduction

Urban mobility refers to the movement of people and goods within the urban space[1]. In large cities such as São Paulo, these movements are complex due to the high number of vehicles, population density, and long distances between origins and destinations[2]. The average daily commute for primary activities is nearly two hours[3], the longest in Brazil[4]. Furthermore, urban mobility disproportionately affects populations of lower socioeconomic status[5], with transportation costs reach-

ing up to 15% of the minimum wage[6], which links to public and urban health. The excessive use of individual motorized transport and the lack of incentives for public transportation or active mobility contribute to problems such as pollution, climate change, hypertension, obesity, and low levels of physical activity[7,8]. Adopting urban planning measures, such as reducing the distances between residences, workplaces, and schools, improving access to public transportation, and promoting mixed-use land development, are effective strategies that can lead to increased physical activity and the prevention of chronic diseases[8].

Integrating different transportation modes is crucial for urban mobility in major urban centers[9]. The "first and last mile" concept comprises the distance from the journey's origin to the public transit station (first mile) and from the station nearest the destination to the final endpoint (last mile)[10] and relies on walking as the primary means for this integration[11]. This yields positive impacts in various domains, such as increased walking[12]. A study conducted in Australia showed that using public transportation can lead to about 38 minutes of walking per week[13] due to the distance to bus stops and stations. This contributes to reducing the risk of obesity[14] and other non-communicable chronic diseases[15]. In addition to the health benefits, there are environmental, economic, and social advantages, such as reduced fossil fuel consumption, lower carbon emissions, decreased spending on fuel, lower travel fares, and improved social interaction[16]. However, most studies demonstrating the benefits of active transport originate from high-income countries. In contrast, this activity may be practiced out of necessity rather than choice in low- and middle-income countries[17].

The COVID-19 pandemic[18] significantly impacted urban mobility[19]. In São Paulo, 35% of people stopped commuting to their primary activities in 2020, resulting in a decrease in bus usage (from 47% to 35%) and an increase in car use (from 20% to 25%) and walking (from 6% to 15%)[3]. In Australia, a study compared the effectiveness of a financial compensation program for bus trips, and the group that received the financial compensation increased their active transport[20]. However, in Japan[21] and Italy[22], walking as a mode of transport decreased, reflecting different pandemic scenarios. Nevertheless, there is a lack of studies on this topic in Brazil.

Given this data, this study aims to: 1) describe the urban mobility of workers in São Paulo during the COVID-19 pandemic; and 2) verify whether the use of public transportation (bus, subway, and train) to commute to work was associated with walking as a mode of transport. Based on these objectives and given the literature, the hypothesis is that there is a positive association between using the public transport system and walking for transportation[12,13].

Methods

Study location

This study was conducted in the city of São Paulo, which has a population of 11,451,999 inhabitants. Its territory spans 1,521.202 km^2, with a population density of 7,528.26 inhabitants/km^2 and a Municipal Human Development Index of 0.805[23]. Regarding urban mobility, according to data from the Origin-Destination Survey conducted in 2017 and 2023 in the metropolitan region of São Paulo, 42 million daily trips were recorded in 2017 (61.5% of which occurred within the city of São Paulo), decreasing to 35.6 million in 2023. Of the trips recorded in 2023, 12.2 million utilized public transportation, and 13 million were made using private vehicles. Additionally, 10.5 million trips were made using non-motorized modes, of which 10.1 million were by walking and 400,000 by bicycle[24].

Study design and sample

A cross-sectional study using data from the second wave of the Health Survey (Inquérito de Saúde - ISA) on Physical Activity and Environment, whose primary objective was to examine the relationships of leisure-time and transportation-related physical activity with the built environment surrounding the residences of individuals living in the city of São Paulo. The cohort uses the baseline data from ISA-Capital 2015, collected between September 2014 and December 2015. It comprised 4,042 individuals aged 12 years or older selected through cluster sampling, considering census tracts and households.

The ISA and Environment study had its second wave conducted between October 2020 and February 2021, during which 3,410 people who had responded to the first wave were contacted. This number reflects the inclusion criterion for the second wave, which required participants to be 18 years old or older. Overall, 1,434 individuals (35.5% of the baseline sample) were interviewed. Among the dropouts, the majority were due to difficulties in locating participants (n = 1,308), relocation outside the city of São Paulo (n = 130), deaths (n = 147), and refusals (n = 107), among other

reasons. The sample retained most of its baseline demographic characteristics, and further details regarding the sampling procedure can be found in the study by Onita et al.[14].

Assessments in the Second Data Collection

Due to the restrictions and risks caused by the COVID-19 pandemic, the second-wave interviews were conducted via telephone survey. The second wave's telephone questionnaire used for data collection maintained the questions on physical activity, self-reported weight, height, and chronic diseases to compare the two periods. New sections of interest, such as urban mobility, were also added[25]. The questionnaire comprised 70 questions divided into 11 thematic sections. The interviewers underwent training coordinated by the research team, including the questionnaire's presentation, reading the manual, discussions on conduct and technical aspects, and simulations with volunteers to assess their performance. Between October 2020 and February 2021, 16 trained interviewers conducted the telephone interviews, which lasted an average of 21.8 minutes (standard deviation = 11.3 minutes). The telephone interviews were conducted using a method similar to the Surveillance System for Risk and Protective Factors for Chronic Illnesses Using a Telephone Survey. Furthermore, conferences were held to verify the quality, validity, reliability, and several stages of database consistency through descriptive and comparative analyses of the baseline assessments with the second wave.

Studies variables

- **Urban mobility during the COVID-19 Pandemic**

The following questions were used to assess urban mobility during the COVID-19 Pandemic: "Are you working from home (home office)?" The answers could be: 1) No; 2) Yes, every day; 3) Yes, a few days a week. For those who answered no or part of the day(s), a second question was asked: "How much time do you spend each day commuting to and from work?" The answer was given in hours and minutes. Finally, "What is the main mode of transportation you use?" The options were: 1) Private car; 2) Ride-hailing app car; 3) Motorcycle; 4) Bicycle; 5) Bus, subway, or train; 6) Walking. In the pilot study that analyzed the stability of these questions, 85% of agreement was found for travel duration and 72.5% for the modes of transport answered.

Regarding commute time to work, the mean and median of the resident population in the city of São Paulo were considered. To establish a cutoff point for categorizing this variable, a time trend conducted by the Our São Paulo Network (Rede Nossa São Paulo) and the Brazilian Institute of Public Opinion and Statistics (Instituto Brasileiro de Opinião Pública e Estatística - Ibope) was used, in which the average commute time was 1 hour and 47 minutes[3]. Consequently, two hours was adopted as the cutoff point in the present study.

Physical activity

Physical activity was assessed using the long version of the International Physical Activity Questionnaire, validated for home and telephone interviews[26]. This questionnaire investigates the pattern of physical activity across different domains in the adult population, based on a typical or usual week, and assesses intensity, daily duration, and weekly frequency. For this study, only transport walking was used, which was classified as follows: walking for an average of ≥30 minutes per day or walking for <30 minutes per day.

Social and demographic variables

The sex classification (male and female) and race/ethnicity obtained at baseline were used. Race/ethnicity classification was based on the criteria proposed by Fontanelli et al.,[27] which is the same as that adopted by racial quota policies (black, brown, indigenous, and others; white and asian).

The age collected in the second wave was analyzed in age groups (young adults: 18 to 39 years old; adults: 40 to 59 years old; and older adults: ≥ 60 years old). Second-wave education was analyzed at four levels (up to the 5th year of elementary school; up to the 2nd year of high school; high school completed; incomplete higher education or above).

Assessment of environmental variables

The city of São Paulo is structured according to its health administrative divisions. Residents are within the jurisdiction of one of the following health coordination regions based on their residential address: Central-West, North, South, East, and Southeast.

Secondary data regarding distance to and the presence of mass transit stations (trains, metro stations, and bus terminals) were obtained from the online public library of geospatial databases maintained by the São

Paulo Municipal Government. These data were georeferenced using network buffers of 1,000 meters from the participants' residential addresses in 2020. The entire data extraction methodology is described in Teixeira et al.,[28]. This buffer distance was selected because 1,000-meter buffers are commonly employed to represent walkable distances of approximately 10 to 15 minutes[12,29].

Data analysis

For descriptive analyses, frequencies were calculated, considering prevalence rates and their respective 95% confidence intervals (95% CI), according to social and demographic characteristics, work modes, transportation modes, travel time, and levels of walking.

The Shapiro-Wilk test was performed to verify adherence to a normal distribution of commuting time from participants' residential addresses to their work. Subsequently, knowing that the data did not adhere to a normal distribution, the Kruskal-Wallis test was applied to verify whether there were differences in medians between different groups regarding social and demographic characteristics, region of residence, transportation mode use, and walking. Means and their respective interquartile ranges were also presented.

Poisson regression was used to determine the prevalence ratios of walking as a means of commuting according to the types of transportation used to go to work (public transportation, such as buses, subways, and trains, compared with individual modes of travel, such as cars, motorcycles, taxis, and ride-hailing services). First, crude models were constructed, and then the models were adjusted for sex, age, and education. Finally, the models were adjusted for large public transportation stations within the buffers (e.g., train stations, subways, and bus terminals) and the health coordination regions where individuals resided. Stata version 16.1 was used for all statistical analyses.

Ethical aspects

The study was approved by the Ethics Committees of the School of Arts, Sciences, and Humanities of the University of São Paulo (CAAE 103969190.0000.5390) and the Municipal Health Department of the city of São Paulo (CAAE 10396919.0.3001.0086).

Results

Of the people interviewed in the second wave (n = 1,434), 728 (50.8%) were working during the COVID-19 pandemic (Table 1). Most workers were up to 59 years old and had completed high school or higher. When comparing the subsample of workers with the total study sample, the proportion of men, young adults (up to 39 years old), and highly educated was higher in the subsample of working participants (Table 1).

Table 1 – Characterization of the total participants assessed in the second wave (n = 1,434) and those who reported being employed (n = 728) during the COVID-19 pandemic, ISA-Physical Activity and Environment, 2020-2021.

	Whole sample (n = 1,434)		Sample of workers (n = 728)	
	%	95% CI	%	95% CI
Sex				
Male	41.4	38.9; 44.0	49.2	45.5; 52.8
Female	58.6	56.0; 61.1	50.8	47.2; 54.5
Age				
Adults aged 18 to 39 years	34.2	31.8; 36.7	45.3	41.7; 49.0
Adults aged 40 to 59 years	30.1	27.8; 32.6	39.3	35.8; 42.9
Older adults (≥60 years)	35.6	33.2; 38.2	15.4	12.9; 18.2
Education				
Up to the 5th year of elementary school	18.5	16.6; 20.6	8.0	6.2; 10.2
Up to the 2nd year of high school	19.4	17.5; 21.6	17.7	15.1; 20.6
High school completed	34.8	32.4; 37.3	38.7	35.2; 42.3
Incomplete higher education or above	27.3	25.0; 29.7	35.6	32.2; 39.2
Race/ethnicity				
White/asian (yellow)	55.7	52.9; 58.3	51.3	47.6; 55.1
Black/brown/indigenous	44.3	41.6; 47.0	48.6	44.8; 52.3
Health coordination region				
North	19.5	17.5; 21.6	19.5	16.8; 22.6
Central-West	14.0	12.3; 15.9	13.0	10.8; 15.7
Southeast	22.7	20.6; 25.0	23.2	20.3; 26.4
South	25.7	23.5; 28.1	25.5	22.5; 28.9
East	18.1	16.2; 20.1	18.7	16.0; 21.7
Physical activity: walking for transportation				
< 30 minutes	65.4	62.9; 67.9	61.2	57.6; 64.7
≥ 30 minutes	34.6	32.1; 37.1	38.8	35.3; 42.4

Regarding the characterization of work and commute patterns (Table 2), the majority performed their activities in person (67%), and a significant portion primarily used public transportation for their commute (46.2%). Furthermore, 39% of workers spent two hours or more going and returning from work.

Table 3 presents the mean and median commute times to and from work, stratified by social and demographic variables, types of transportation used, and walking as a means of commuting. Residents of the

Table 2 – Work models and commuting patterns from home to workplace among workers (n = 728), ISA-Physical Activity and Environment, 2020-2021.

	Sample of workers (n = 728)	
	%	95% CI
Work models		
On-site work	66.6	63.1; 70.0
Hybrid work (on-site and remote)	24.6	21.6; 27.9
Remote work/home office	8.8	6.9; 11.1
Means of transportation to work*		
Motorized private vehicles	35.5	31.6; 39.7
Active commuting (Bike or Walk)	18.3	15.3; 21.8
Public transport (bus, subway, or train)	46.2	42.0; 50.4
Commute time to work*		
< 2 hours	61.0	56.8; 65.2
≥ 2 hours	39.0	34.8; 43.2

*Only for on-site or hybrid models of work (n = 516)

South and East regions, public transportation users, and those who actively walked less than 30 minutes per day had the highest mean and median commute times.

In Table 4, it can be seen that the prevalence ratios for walking as a means of transportation were statistically significant for those who used public transport when compared to those who used individual modes of travel, regardless of social and demographic variables, the region of residence, or whether or not there was availability of large stations and transport within one kilometer of their homes.

Discussion

The main results showed that most people in this study worked in person during the COVID-19 pandemic, used public transportation such as buses, subways, and

Table 3 – Means and medians of commute times from home to workplaces according to social and demographic variables, transportation modes used, and transport walking for individuals who worked on-site or in a hybrid model (n = 516), ISA-Physical Activity and Environment.

Variables	Mean (min)	Standard error (min)	Median (min)	Interquartile range (min)	p
Sex					
Male	91.7	70.7	80	30-120	0.542
Female	99.1	81.5	80	35-140	
Age					
Adults aged 18 to 39 years	96.7	72.6	80	30-120	
Adults aged 40 to 59 years	100.9	84.2	85	30-140	0.053
Older adults (≥60 years)	70.8	55.7	60	40-180	
Education					
Up to the 5th year of elementary school	120	94.2	120	30-200	
Up to the 2nd year of high school	92.3	84.4	60	30-120	0.279
High school completed	93.2	75.3	75	30-120	
Incomplete higher education or above	94.5	65.3	90	40-120	
Race/ethnicity					
White/asian (yellow)	93.3	74.3	80	30-120	0.554
Black/brown/indigenous	98.7	78.9	80	32.5-140	
Health coordination region					
North	78.3	69.8	60	30-120	
Central-West	64	49.9	45	30-90	
Southeast	86.8	63.6	75	35-120	0.001
South	122.2	88.1	120	40-180	
East	106.4	80.4	90	40-150	
Means of transportation to work					
Motorized private vehicles	73.6	63.2	60	30-120	
Active commuting (Bike or Walk)	31.5	25.8	30	15-40	0.001
Public transport (bus, subway, or train)	135.6	75	120	90-180	
Physical activity: walking for transportation					
< 30 minutes	104.9	110	90	40-150	0.001
≥ 30 minutes	89.9	90	60	30-120	

p = Kruskal-Wallis test.

Table 4 – Association between transport walking and the types of transportation modes used during the COVID-19 pandemic, ISA-Physical Activity and Environment, 2020-2021 (n = 433*).

Variables	Types of transport modes Private car, ride-hailing app car, taxi, motorcycle	Prevalence ratio (95% CI) Bus, subway, or train	p
Model 1 crude	Ref	1.58 (1.22; 2.04)	0.001
Model 2**	Ref	1.82 (1.37; 2.43)	0.001
Model 3***	Ref	1.74 (1.31; 2.31)	0.001
Model 4****	Ref	1.72 (1.31; 2.28)	0.001

The effect measure is expressed by the Prevalence Ratio and respective 95% confidence intervals (95% CI). *Analyses were conducted only for those who were using either public transportation or individual transportation to go to and from work; **Model adjusted for: age, sex, education level, race/ethnicity; ***Model adjusted for: age, sex, education level, race/ethnicity, and health coordination region where the participant resided; ****Model adjusted for: age, sex, education level, race/ethnicity, health coordination region where the participant resided, and the presence of a large public transportation station within the 1,000-meter buffer.

trains to commute, and spent less than two hours getting to and from work. People living in the South and East health regions or those who used public transportation spent more time commuting. Participants who used public transport had a higher prevalence of walking for transportation (prevalence ratio of 1.58 in the crude model and 1.72 in the final adjusted model) than those who used individual modes of travel.

The results of this study showed that 50.8% of the sample was working during the COVID-19 pandemic, a result that is close to that found in the population-based study Telephone Survey of Risk Factors for Chronic Noncommunicable Diseases During the Pandemic in 2022. The distributions according to education level were similar; however, in the present study, there was a lower proportion of black and brown people working[30].

It was observed that most workers in this study had to commute to their workplace, and the smallest proportion of workers were exposed to the recommended safety model for this period: remote work/home office. According to data from the National Household Sample Survey (*Pesquisa Nacional por Amostra de Domicílios* – PNAD)[31], approximately 10% of the Brazilian population worked entirely from home during the COVID-19 pandemic, like what was found in this study. Observational studies and the PNAD-COVID-19 report have shown that workers who had to leave home during the COVID-19 pandemic were often tied to "essential" jobs, such as healthcare professionals, or had lower levels of education[31,32].

Interestingly, public transportation was the primary mode, which may suggest limited transportation options. However, the metropolitan region of São Paulo and Lisbon showed a sharp decline in the use of subways, trains, and buses during the pandemic[24,33]. For example, a 2020 survey by *Rede Nossa São Paulo*[3] showed a significant drop in bus use and a considerable increase in walking, from 6% in 2019 to 15% in 2020. The main reason for this was overcrowding on public transportation. In fact, 18% of the workers in this study predominantly walked or cycled during this period.

Regarding commute time, it was observed that 39% of the sample in the present study spent two hours or more commuting (round trip). This indicates that even during the pandemic period, with reduced traffic congestion due to social distancing measures, the main factor remained the considerable distance between people's homes and workplaces. Consequently, individuals residing in the South and East regions of the city were the groups with the longest commute times. In contrast, those living in the Central-West region spent less time commuting. These findings are consistent with the historical data from *Rede Nossa São Paulo*[3], which also reveals an inequality in the distribution of jobs and income across the city, with the highest concentration historically located in the central regions[34]. This situation continues to adversely affect those living in more peripheral areas, who must travel long distances daily to perform their work activities. Furthermore, individuals living in peripheral regions of São Paulo City have a lower socioeconomic status[34], while opportunities for active transportation choices are more common and accessible for people of higher socioeconomic levels[35]. This represents a long-standing issue in the city of São Paulo, hindering access to the city and the right to the city for its more peripheral and vulnerable population.

Public transportation users in the present study walked more for their commute than those who predominantly used private transportation. Several factors may explain this association: 1) the concept of the "first and last mile"[10], where walking to and from public transportation stops is a determining factor[36]. Additionally, as cities expand, mobility related to public transportation services, which follow fixed routes, has become a challenge, especially for individuals without private vehicles who must combine multiple modes of transportation to reach their destinations[37]; 2) walking

is the most accessible type of physical activity and is commonly used to integrate with other transportation modes, particularly public transportation[11]. It is important to note that the results remained the same even after adjusting for significant social, demographic, and environmental variables (e.g., large stations near participants' households). Supporting these findings, a randomized trial conducted with adults in Australia showed that financial incentives for using public transportation increased walking and cycling for transportation, highlighting that these types of physical activities function integratively[20] but are influenced by the high cost of public transportation.

Therefore, it is always important to discuss whether this walking is done by choice or necessity, as this directly impacts public health[17,38]. Beyond issues such as pollution, insecurity, stress, and others, in the context of the COVID-19 pandemic, this walking likely mainly occurred out of necessity. And despite the benefits, these individuals were more exposed to COVID-19 contamination due to the use of public transportation[39], as the risk of infection was higher in crowded vehicles and during longer commutes[39], and typically, those are the daily characteristics of public transportation in the city of São Paulo[3,4]. Nevertheless, it is worth emphasizing that in many cases, transport-related physical activity provides benefits at the individual, social, collective, and environmental levels[14-16]. Further exploring the issue of necessity versus choice in future studies is of utmost importance.

In this regard, it is imperative to study actions and policies that encourage and promote the use of public transportation, such as expanding the fleet and routes, improving infrastructure, including the expansion of exclusive bus corridors[40], and implementing fare-free policies[11]. A fare-free initiative is occurring on Sundays in the city of São Paulo, which promotes the right to move around and occupy urban spaces, expanding citizens' choices regarding transportation modes and transport-related physical activity. Furthermore, it is highly relevant to develop and democratize access and proximity to major public transportation stations[40], especially in more peripheral areas of the city.

It is essential to highlight some limitations of this study. Data collection was conducted only during the COVID-19 pandemic, which prevents comparisons with other periods and may not reflect the normality of the post-pandemic era. Additionally, information on occupation type, workplace addresses, and reasons for using different transportation modes were not collected, which would provide clearer insights into whether walking as a form of commute was done by choice or necessity. Finally, as a cross-sectional study, it does not allow for causal inference. Therefore, longitudinal studies are still needed to determine whether public transportation use is indeed a determinant of walking for transportation.

Nevertheless, this study provides evidence and fosters discussion on how work activities were carried out, commute modes, and their relationship with walking as a form of transportation among adults living in a megacity like São Paulo during the COVID-19 pandemic.

Most participants in this study worked in person during the COVID-19 pandemic and commuted using public transportation such as buses, subways, and trains. Those residing in the South and East regions of São Paulo or who used public transportation spent more time commuting. Public transportation users walked more as a form of transportation than private transportation users, regardless of social, demographic, and environmental variables. These results highlight the need for concrete strategies, such as expanding public transportation networks, implementing fare-free policies, and improving service quality and coverage in peripheral regions. The integration between public transportation and physically active modes should be incorporated into urban planning and mobility master plans through the improvement of sidewalks, bike lanes, and safe crossings. Policies promoting density and zoning oriented toward proximity between housing, work, and services, as well as the creation of local active mobility observatories, can help reduce inequities in access to the city and promote healthier and more sustainable communities[40].

Conflict of interest

The authors declare no conflict of interest.

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Authors' contribution

Goulardins GS: Conceptualization; Methodology; Data curation

and Software; Formal analysis; Investigation; Project administration; Visualization; Writing – original draft; Writing – review & editing; Final approval of the manuscript. Knebel MTG: Conceptualization; Methodology; Resources; Data curation; Project administration; Writing – original draft; Writing – review & editing; Final approval of the manuscript. Onita BM: Methodology; Formal analysis; Data curation; Project administration; Writing – original draft; Writing – review & editing; Final approval of the manuscript. Teixeira IP: Methodology; Data curation and Software; Validation; Resources; Writing – original draft; Writing – review & editing; Final approval of the manuscript. Rodrigues EQ: Methodology; Investigation; Project administration; Writing – original draft; Writing – review & editing; Final approval of the manuscript. Oliveira ES: Methodology; Writing – original draft; Writing – review & editing; Final approval of the manuscript. Florindo AA: Conceptualization; Methodology; Formal analysis; Investigation; Resources; Supervision; Project administration; Funding acquisition; Writing – original draft; Writing – review & editing; Final approval of the manuscript.

Declaration regarding the use of artificial intelligence tools in the article writing process

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The data of this study is available on demand from referees.

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Reviewers' assessment

The reviews of this article were originally conducted in Portuguese. This version has been translated using ChatGPT and subsequently reviewed by the Chief Editors.

Reviewer A

Ana Luiza Favarão Leão
Universidade Estadual de Londrina

Format

- Does the article comply with the manuscript preparation rules for submission to the *Revista Brasileira de Atividade Física e Saúde*?
  Yes
- Regarding formal aspects, is the manuscript well-structured, containing the sections: introduction, methods, results, and discussion (conclusion as part of the discussion)?
  Yes
- Is the language appropriate, and is the text clear, precise, and objective?
  Partly
- Was any evidence of plagiarism observed in the manuscript?
  No
  Suggestions/comments:
- The text follows the basic structure required by the journal, but some passages could be reorganized for greater clarity, especially in the introduction (word order in the sentence between lines 27–30) and the discussion (logical order of ideas in the paragraph on page 10). The language is appropriate but could be more objective and fluid in some sections.

Abstract

- Are the abstract and resumo adequate (containing: objective, information about study participants, studied variables, main results, and a conclusion) and do they reflect the content of the manuscript?
  Yes
  Suggestions/comments:
- The abstract and resumo present all essential elements. I only suggest minor editing for greater clarity and objectivity, mainly in the results section (lines 19–26). It could also better highlight the social implications of the findings for public policies and urban equity.

Introduction

- Was the research problem clearly stated and defined?
  Yes
- Is the research problem adequately contextualized in relation to available knowledge, moving from general to specific?
  Partly
- Are the reasons justifying (including the authors' assumptions about the problem) the need for the study well established in the writing?
  Yes
- Are the references used to support the presentation of the research problem current and relevant to the theme?
  Partly
- Was the objective clearly stated?
  Yes
  Suggestions/comments:
- The text addresses urban mobility well, but some sentences are confusing and could be reorganized for better understanding. It would be helpful to diversify the examples of factors related to active mobility and strengthen the justification for the study's relevance. The literature review could also be expanded to include more recent work.

Methods

- Are the methodological procedures, in general, adequate for the research problem?
  Yes
- Are the methodological procedures adopted in the study sufficiently detailed?
  Yes
- Was the procedure for selecting or recruiting participants adequate for the problem studied and clearly described?
  Yes
- Were details presented on the instruments used for data collection, their psychometric qualities (e.g., reproducibility, internal consistency, and validity), and, when relevant, on the operational definition of variables?
  Yes

- Is the data analysis plan appropriate and adequately described?
  Yes
- Were the inclusion and/or exclusion criteria for participants described and adequate for the study?
  Partly
- Did the authors provide clarifications about the ethical procedures adopted in the research?
  Yes

Suggestions/comments:

- The methods are adequate but could be more detailed regarding inclusion/exclusion criteria and participant selection.

Results

- Is the use of tables and figures appropriate and do they help convey the study's results?
  Yes
- Is the number of illustrations in accordance with the journal's submission guidelines?
  Yes
- Was the number of participants at each study stage, as well as the number and reasons for losses and refusals, presented?
  Partly
- Are the participants' characteristics presented and sufficient?
  Yes
- Are the results adequately presented, highlighting the main findings and avoiding unnecessary repetitions?
  Yes

Suggestions/comments:

- Results are well presented, with appropriate tables and figures. However, other important points shown in the tables could be better explored.

Discussion

- Are the main findings of the study presented?
  Yes
- Are the strengths and limitations of the study presented and discussed?
  Yes
- Are the results discussed in light of the study's limitations and existing knowledge?
  Yes
- Do the authors discuss the potential contributions of the findings to scientific development, innovation, or real-world interventions?
  Yes

Suggestions/comments:

- The main findings are presented, but in some points the analysis is descriptive. It is important to further explore the structural implications of socio-spatial segregation on urban mobility and health. Relating the findings to the concepts of the right to the city and spatial justice would strengthen the discussion. It would also help to better clarify the impacts of long commuting times and unequal access to active transport options on physical, mental, and social health.

Conclusion

- Was the study conclusion presented appropriately and consistent with the study objective?
  Yes
- Is the study conclusion original?
  Yes

Suggestions/comments:

- The conclusion is appropriate and consistent with the results. It could, however, provide more contextualized and practical recommendations.

References

- Are the references updated and sufficient?
  Yes
- Are most references from original articles?
  Yes
- Do the references comply with the journal's rules [quantity and format]?
  Yes
- Is in-text citation adequate, i.e., do claims cite references that substantiate them?
  Yes

Suggestions/comments:

- References are relevant but could be updated in the introduction. They comply with the journal's formatting rules.

Comments to the Author

General assessment

- The topic is relevant, and the research is timely, using survey data and applying appropriate statistical methods. However, the manuscript's writing could be improved for clarity in some parts of the introduction and discussion. The methodological detail could also be slightly expanded. I recommend revision, focusing on restructuring confusing sentenc-

es, reorganizing the logical flow of ideas in a key paragraph of the discussion, further exploring equity issues, and making small methodological and conclusion adjustments to strengthen the study's contribution.

Detailed assessment

Introduction

- Paragraph 2, lines 6–9: The literature review could be expanded to include more recent studies on active mobility and public transport in the post-COVID context, as well as mechanisms explaining the positive effect of public transport on walking (e.g., urban form, distances walked to stations).
- It would be interesting to add 2–3 more references and a sentence clarifying the hypothesized causal relationship.
- Page 2, lines 27–30: The sentence addressing the reduction of distances between home and workplaces, connectivity, and mixed land use is unclear. The order of factors makes the idea confusing. I suggest rewriting it, separating the concepts (urban compactness, land-use diversity, proximity of destinations) and giving better examples of how these factors promote active mobility.

Methods

- Although the method is generally appropriate, clear information on participants' inclusion/exclusion criteria is missing. If there were no relevant exclusions, this should be stated.
- Additionally, it could be detailed whether there were losses or refusals during data collection and how they were handled in the analysis (also connected to the results section).

Results

- If available, it would be useful to explicitly present the number and reasons for sample losses or refusals, ensuring greater transparency about participant flow in each study stage.
- Table 1 shows relevant sociodemographic differences (e.g., higher proportion of young workers, higher education level), which could be explored in the text, commenting on inequalities in access to work and active mobility.
- Table 3 shows longer commuting times for those using public transport, but this relationship is neither mentioned in the results section nor interpreted later. A brief note on average values and implications for time invested in mobility should be included.

Discussion

- Page 10, lines 17–23: The section on choice versus necessity of public transport during the pandemic is central to the discussion. Currently, the text mentions greater exposure to COVID-19 risk but could be expanded to highlight other negative externalities of public transport use, such as pollution, stress, traffic safety concerns, etc.
- Page 10, lines 27–30: The sequence of ideas discussing "fare-free policy," "fleet expansion," and "infrastructure improvement" is not very logical. Presenting fare-free policy before discussing expansion and service quality does not reflect the operational reality of public transport. I recommend restructuring the paragraph to present first the need for expansion and quality improvement, then diversification of options, and finally fare policies.
- The discussion could engage more with the actual transportation policy context in São Paulo (e.g., recent fare-free policy proposals, investments in bus corridors and bike lanes, integration with active modes).
- It would also be useful to cite health implications not only related to physical activity but also to reduced pollution, emissions, equity in access, and the right to the city.
- The discussion does not sufficiently address socio-spatial inequalities in São Paulo, where the historical peripheralization of low-income housing is directly associated with longer commutes, dependence on public transport, and reduced access to urban opportunities. This reality undermines the right to the city, perpetuates socio-spatial exclusion, and increases commuting times, as shown in Table 3.
- The text mentions peripheralization and inequality in job distribution in São Paulo (page 9, paragraph 3), but the discussion remains descriptive and does not explore the social implications/drivers of this phenomenon. I recommend deepening this analysis by linking it to socio-spatial segregation and its structural effects on urban mobility and health, the concept of the right to the city, and debates on spatial justice and social exclusion (which largely shape and perpetuate unequal urban mobility). Public transport and housing policies that could reduce these inequalities, improve urban accessibility, and promote equitable commuting should also be discussed.
- Conclusion/last paragraph of the discussion: The

conclusion is consistent but could be strengthened with more practical public policy recommendations—pointing to concrete interventions (e.g., encouraging modal integration, proximity/urban compactness policies in land-use planning through instruments such as zoning and master plans, improving public transport quality).

Final decision

- Major revisions required

Reviewer B

Anonymous

Abstract

- On lines 10 and 11 of page 1, it is unclear whether the survey (ISA) stands for Inquérito de Saúde and "Physical Activity and Environment" are extensions, or if it means Inquérito de Saúde, Atividade Física e Ambiente. In the first case, the extension must be identified. In the second case, a comma is missing to continue the description, in addition to the need to insert the acronym after the word "Ambiente."

Introduction

- Between lines 21 and 24 of page 2, the excerpt "Furthermore, a statistically significant association was found between being a user of public transport and walking as a means of transportation, for both the crude and adjusted models." could be improved for better agreement.
- Between lines 27 and 30 of page 2, the sentence "It is interesting to note that those who traveled in this study mostly did so using public transportatio, suggesting they likely had no other transportation option. However, the metropolitan areas of São Paulo and Lisbon showed a sharp decline in the use of subways, trains, and buses during the pandemic[24,33]." conveys the idea that simply reducing these distances can be a strategy to increase physical activity. However, these are not direct actions, but rather consequences of urban planning strategies that may affect physical activity.
- The sentence located between line 32 on page 2 and line 3 on page 3 needs revision, as it is incoherent. The author defines the concept of "first and last mile" but does not connect it with the end of the sentence, which cites walking as the most common means of integrating transport modes.
- On line 4 of page 3, the acronym "PA" (physical activity) lacks a connection with "as a form of commuting." The word "as" could be used.
- On line 12 of page 3, the preposition "by" is missing before the word "necessity."

Methods

- In the section "Study site," the author describes data from the Origin-Destination Survey. It is not clear whether these data are part of the study results—in which case, the section title should be changed—or whether they are contextual information, in which case they should be placed in the introduction and/or discussion. If the information belongs in the methods, it is necessary to specify which trips were used and in which year.
- On line 22 of page 5, the last 5 words were not properly deleted.
- In the "Physical Activity" subsection of the methods, the word "Questionnaire" is misspelled.

Discussion

- Between lines 6 and 9 of page 9, the passage "It is interesting to note that those who traveled in this study mostly did so using public transportatio, suggesting they likely had no other transportation option. However, the metropolitan areas of São Paulo and Lisbon showed a sharp decline in the use of subways, trains, and buses during the pandemic[24,33]." is confusing. The word "provável" ("likely/probable") suggests a very high probability. Since this was not tested in the study, it is recommended to use more cautious wording, such as "this suggests a limitation in transport options."

Final Decision

- Mandatory corrections