

Article

Sustainable Placemaking and Thermal Comfort Conditions in Urban Spaces: The Case Study of Avenida dos Aliados and Praça da Liberdade (Porto, Portugal)

Hélder Silva Lopes ^{1,2,*} , Paula C. Remoaldo ¹ , Diogo Guedes Vidal ^{3,4} , Vítor Ribeiro ¹, Lígia Torres Silva ⁵ 
and Javier Martín-Vide ² 

¹ Laboratory of Landscape, Heritage and Territory (Lab2PT), Associate Laboratory for Research and Innovation in Heritage, Arts, Sustainability and Territory (IN2PAST), Department of Geography, Institute of Social Sciences (ICS), University of Minho, 4800-058 Guimarães, Portugal; premoaldo@geografia.uminho.pt (P.C.R.); vitor.geografia@gmail.com (V.R.)

² IdRA—Climatology Group, Department of Geography/FGH, University of Barcelona, 08001 Barcelona, Spain; jmartinvide@ub.edu

³ Centre for Functional Ecology—Science for People and the Planet (CFE), Associate Laboratory TERRA, Department of Life Sciences (DCV), University of Coimbra, 3000-456 Coimbra, Portugal; diogoguedesvidal@hotmail.com

⁴ Department of Social Sciences and Management, Universidade Aberta, 1250-100 Lisbon, Portugal

⁵ Centre for Territory, Environment and Construction (CTAC), School of Engineering, University of Minho, 4800-058 Guimarães, Portugal; lsilva@civil.uminho.pt

* Correspondence: helderlopes@geografia.uminho.pt

Abstract: The urban microclimate of Avenida dos Aliados and Praça da Liberdade was subjected to comprehensive examination through twelve measurement campaigns at six strategic observation points over the course of two seasons, namely summer and winter, between 2019 and 2020. The study employed an objective approach based on measurements to evaluate key microclimatic factors, including air temperature, which ranged from 15 °C in winter to a peak of 38 °C in summer, and Relative Humidity (RH), which varied from 50% to 85%. Additionally, wind speed was recorded between 1.0 m/s and 2.5 m/s, along with solar radiation levels, which significantly impacted Surface Temperatures (T_{surf}), reaching up to 38.0 °C in some areas. A parallel subjective survey questionnaire was conducted with 123 participants. In particular, the preference for shaded areas was highlighted through a thermal sensation map, with some places in Praça da Liberdade being a favored spot during summer due to its vegetation and lower T_{surf} . The study identified solar exposure, wind patterns, and T_{surf} as the key determinants of thermal comfort. It is noteworthy that shaded areas, particularly those with a substantial amount of greenery, were found to alleviate discomfort from the heat, thereby making them the preferred choice for pedestrians. Furthermore, the study underscored the significance of incorporating adaptive elements, such as greenery, shading structures, and ventilation corridors, into urban design to enhance comfort across different seasons. Results contribute with valuable insights for urban planners. The data indicate that urban design should prioritize the inclusion of pedestrian-friendly elements, such as shaded walkways and seating areas, to promote the active use of public spaces. This approach is particularly relevant in the context of climate change, where seasonal variations and increasing temperatures may exacerbate discomfort in urban environments.

Keywords: placemaking; thermal comfort analysis; pedestrian behavior; objective and subjective dimensions; adaptation



Academic Editors: Xiang Zhao and Luis Hernández-Callejo

Received: 23 November 2024

Revised: 23 January 2025

Accepted: 31 January 2025

Published: 7 February 2025

Citation: Lopes, H.S.; Remoaldo, P.C.; Vidal, D.G.; Ribeiro, V.; Silva, L.T.; Martín-Vide, J. Sustainable Placemaking and Thermal Comfort Conditions in Urban Spaces: The Case Study of Avenida dos Aliados and Praça da Liberdade (Porto, Portugal). *Urban Sci.* **2025**, *9*, 38. <https://doi.org/10.3390/urbansci9020038>

Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Placemaking, grounded in the knowledge of renowned authors like Whyte (1980) [1], Gehl (1987) [2], Carmona (2014, 2019) [3,4], and Wesener et al. (2020) [5], emphasizes an interdisciplinary approach, considering physical, social, ecological, and cultural qualities in urban environments. Over recent decades, placemaking goals have shifted, notably in adapting public spaces to diverse uses, influenced by pressures that challenge traditional urban design [6–8]. The concept of sustainable placemaking emerges here as a key approach that integrates urban design with environmental, social, and cultural considerations to create resilient public spaces. Gehl's (1987) [2] work underlines the importance of public spaces that promote health and well-being through balanced social–environmental interactions.

Whyte (1980) [1] demonstrated that well-designed spaces with comfortable seating and greenery attract more users, emphasizing the importance of designing appealing public areas. This interdisciplinary approach, highlighting physical, social, and ecological factors, has raised questions on sustainable placemaking [9]. Policy shifts over decades reveal evolving goals in adapting spaces for both residents and visitors [10,11].

Both qualitative and quantitative factors are crucial for evaluating comfort in public spaces. This is supported in Costa (2013) [12], Nouri & Costa (2017) [13], Monteiro et al. (2018a, 2018b) [14,15], and Madureira et al. (2021) [16], who advocate for specific recommendations in urban planning. Place design should consider psychological and sociological perceptions in context-sensitive environments [17,18].

Erell et al. (2011) [19] identified three types of preferences in public spaces: (i) climatic environment, influenced by Air Temperature (AT), solar radiation, relative humidity (RH), and wind patterns; (ii) built environment, shaped by urban structures; and (iii) human environment, affecting thermal preferences through behavior and satisfaction thresholds. From these analyses, six key indicators are identified: (1) microclimatic data; (2) urban morphology; (3) vegetation and recreational areas; (4) user choice; (5) surrounding context; and (6) climate risk scenarios. Microclimatic data, such as AT, T_{surf} , and RH play a pivotal role in urban comfort [20,21]. T_{surf} refers to the temperature measured on the external surfaces of materials, such as pavements, walls, or other urban structures, which absorb and re-radiate heat from solar radiation. The Height–Width Ratio (H/W) and Sky View Factor (SVF) are also significant, affecting solar exposure and shaded areas [22–24].

As climate change impacts urban planning, green spaces are recognized for enhancing comfort [20,25]. Tree configurations and species, affecting shading and cooling, are crucial, as is vegetation choice based on growth characteristics [26,27].

For this, environmental context and larger-scale meteorological behavior are essential for assessing comfort, with factors like proximity to green spaces and permeability affecting public space use [28].

Considering future climate trends and Urban Heat Island (UHI) effects, public space design strategies should focus on creating socially vibrant, economically viable, and environmentally adapted areas. Lopes et al. (2022) [11] emphasized the need for proactive climate adaptation in Porto (Portugal), highlighting a cyclical process of evaluation and intervention to ensure ongoing resilience.

The importance of designing urban spaces that respond effectively to local climatic conditions has been widely recognized in recent years. Sustainable urban planning increasingly incorporates bioclimatic principles to address the challenges posed by Urban Heat Islands (UHIs) and climate change. Notably, studies such as Nouri & Costa (2017) [20] have demonstrated the effectiveness of integrating bottom-up methodologies that combine microclimatic measurements and subjective perceptions of thermal comfort. Their work, focusing on Rossio Square in Lisbon, highlighted the importance of identifying microclimatic risk factors and translating these into actionable design interventions, such as

shading and vegetation configurations, to improve pedestrian comfort during extreme summer conditions.

This study builds on these approaches, expanding them to a comparative analysis of seasonal variations in thermal comfort across summer and winter in Avenida dos Aliados and Praça da Liberdade. The emphasis on linking objective data with subjective perceptions aligns with Nouri & Costa's (2017) framework [20], which underscores the need for urban design solutions that are both climatically adaptive and contextually specific.

This study explores the intersection of placemaking, climate change, and leisure in this territory (Porto, Portugal). Urban microclimate measurements are key to understanding factors affecting thermal comfort and quality of life. Studies by Santamouris et al. (2013) [22] and Erell et al. (2011) [19] reinforce the importance of detailed measurements across urban contexts to inform sustainable urban planning. Furthermore, it is important to use subjective methods to explore the individual perception (namely, mental maps or surveys) [10,29–31].

To address these considerations, the study aims to explore the following research questions:

What are the differences in thermal comfort perception between summer and winter in Porto's public spaces?

Which microclimatic features most influence user behavior in public spaces such as Avenida dos Aliados and Praça da Liberdade?

Correspondingly, the study tests the following hypotheses:

H1: *There are significant seasonal differences in thermal comfort perception among users of urban public spaces, with higher discomfort levels reported in summer compared to winter.*

H2: *Microclimatic factors, including solar exposure, wind patterns, and shaded areas, significantly influence user behavior and preference in public spaces.*

The study is based on the collection of microclimatic data in Avenida dos Aliados and Praça da Liberdade, areas potentially frequented by individuals, between the years 2019 and 2020. Measurements were taken during the summer and winter seasons of both years in 8 fieldwork campaigns conducted between 10:00 GMT + 00 and 17:00 GMT + 00, allowing for a comprehensive analysis of climatic conditions. Additionally, the study incorporates the perspective of individuals through surveys and mental maps revealing their perceptions of hot and cool areas, along with observation method conducted by the research team.

The analysis of the relationship between microclimatic conditions and human behavior is derived from this approach, considering factors such as movement and dwell time in different points of the study area. The results reveal distinct microclimatic patterns throughout the seasons, with significant influences from solar exposure, ventilation, and shaded areas. The analysis of human preferences highlights discrepancies between objective and subjective thermal comfort conditions. Wind patterns and the relationship between air temperature (AT) and Surface Temperature (T_{surf}) emerge as crucial elements in understanding thermal comfort. Furthermore, the study underscores the importance of greenery and tactical urbanism in creating more pleasant spaces, especially during periods of climatic variations.

This paper is structured into five sections. Following this introductory point, Section 2 details the methods adopted for data collection and analysis, while the results (Section 3) highlight the main relationships between public space use and microclimatic measurements. The discussion and conclusions, in Section 4, interpret the results in the theoretical and

practical context, summarizing the study's contributions and suggesting possible future directions in integrating placemaking, climate change, and urban planning.

2. Materials and Methods

2.1. Case Study

The municipality of Porto is part of the Porto Metropolitan Area (PMA) and is located in the northwest of mainland Portugal. It is the second most economically dynamic municipality in Portugal and the second most populated area in Portugal (Figure 1). This municipality has a privileged location on the coast, with the Atlantic Ocean to the west and the river Douro to the south. It also faces the Atlantic Ocean, with an altitude range of 160 m. It has a temperate maritime climate, with an average AT between 15 °C and 25 °C. According to the Köppen and Geiger climate classification system, Porto is in the Csb zone (Lopes et al., 2021) [10].

This study was conducted on Avenida dos Aliados and Praça da Liberdade, located in the center of Porto. The choice of Avenida dos Aliados and Praça da Liberdade was made for strategic reasons in terms of urban characteristics and because it is one of the areas with the highest convergence of individuals. It should be noted that this area is considered a potential hub for pedestrians throughout the year, especially due to its importance in terms of intra- and inter-mobility. The presence of buses (some of which are tourist buses), the metro station that connects to large areas of the city, as well as the proximity of the railway line (S. Bento station), allow a considerable number of people to pass through this avenue. They can stay while waiting for a bus, walk along the avenue, enjoy a terrace to observe the landscape, or simply have lunch, a snack, or dinner. This area is subject to different bioclimatic comfort conditions (daily and in different seasons), depending on its diverse characteristics. It is important to note that research has already been conducted in this area of study. This research has demonstrated the relevance of a more focused study to understand the objective and subjective dimensions of the use of public space. Firstly, the study conducted by Lopes et al. (2021) [10] revealed the thermal perceptions of 563 tourists. Then, a more recent study revealed that this area is one of the most problematic for thermal comfort in the city of Porto [32].

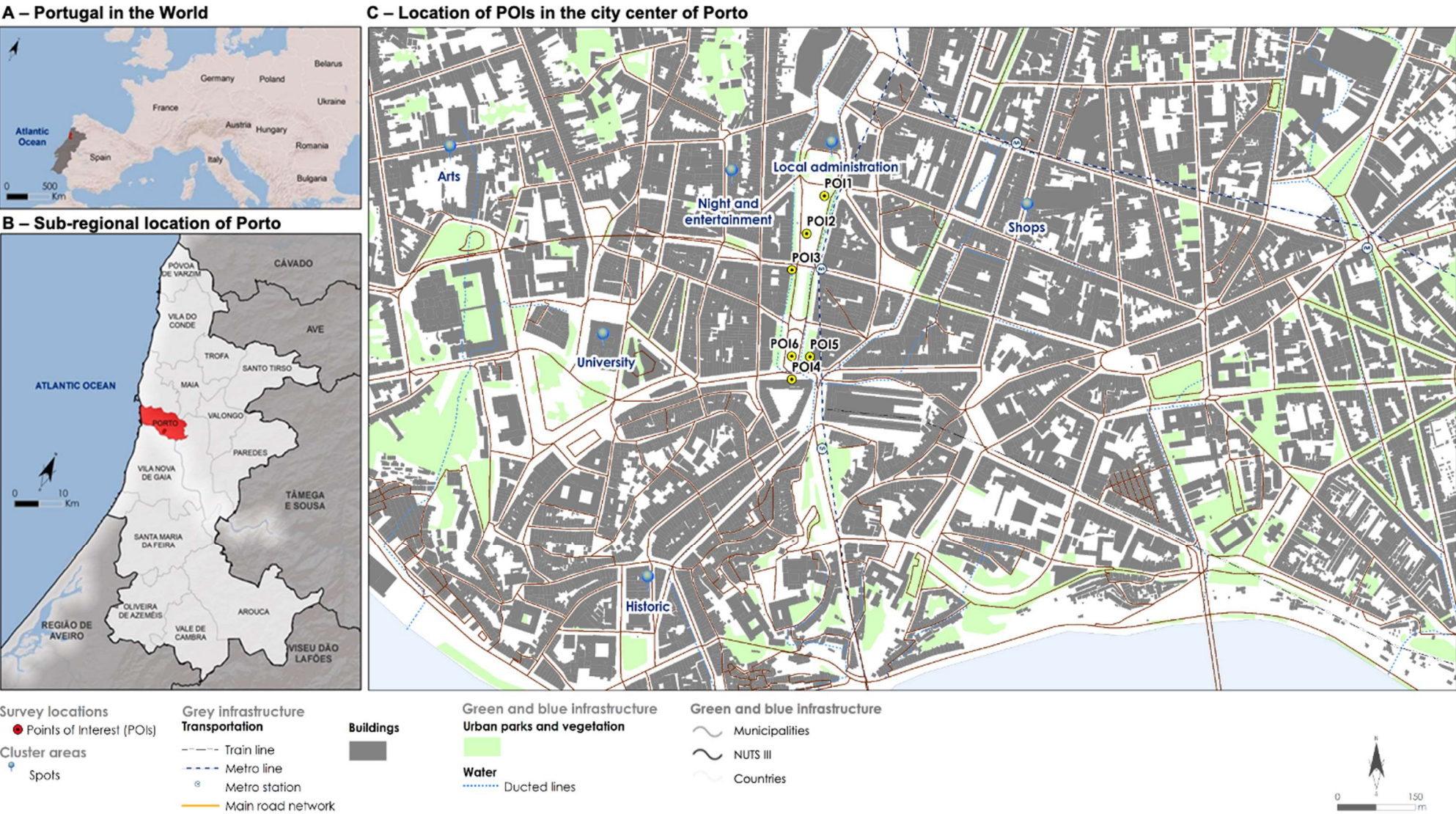


Figure 1. Study area. Avenida dos Aliados and Praça da Liberdade (C); Portugal in the world (A) and sub-regional location of Porto (B). Source: own elaboration.

2.2. Evaluation Assessment Framework

The evaluation assessment framework uses an objective and subjective approach, drawing inspiration from methodologies applied by Nouri & Costa (2017) [20]. The objective assessment was made using microclimate measurements, while the qualitative approach employs the behaviors' mapping and perceptions of individuals in the study area. The selection of microclimatic measurements aligns with the research objectives by providing objective data on thermal conditions, which is critical for understanding seasonal and spatial variations in comfort levels. These methods were chosen because they offer reliable, quantifiable metrics of environmental conditions, such as AT, RH, Wx, and ST, which are directly linked to thermal comfort perception. The inclusion of multiple Points of Interest ensures the capture of microclimatic diversity, which is crucial for developing targeted urban design interventions. On the other hand, the subjective approach, including mental mapping and behavior observation, was selected to capture the individual and nuanced perceptions of thermal comfort, which cannot be quantified through instrumental measurements alone. This method ensures the integration of the human dimension in urban planning by revealing behavioral patterns and individual preferences. Collecting data through surveys and mental maps provides insights into how microclimatic conditions interact with subjective experiences, fulfilling the study's goal of understanding both objective and subjective factors influencing public space use.

2.3. Objective Approach

The microclimatic measurements were conducted at six strategically selected Points of Interest (POIs) on Avenida dos Aliados and Praça da Liberdade (Figure 2). These points were chosen to reflect the diversity of microenvironments in the area, allowing for a comprehensive analysis of how urban morphology and vegetation cover influence thermal comfort. For instance, POI 1 represented a shaded environment due to a linear plantation of magnolia trees, while POIs 2, 3, and 6 were open paved areas with exposure to solar radiation and proximity to traffic lanes. Transitional zones, such as POIs 4 and 5, featured varying levels of vegetation and urban structures, providing an intermediate perspective on urban conditions (Table 1).

Measurements were conducted over a 12-day period, distributed across the summer of 2019, the winter of 2019–2020, and the summer of 2020, capturing seasonal variations in thermal comfort. Data collection took place between 10:00 GMT + 00 and 17:00 GMT + 00, with six measurement cycles per day at each POI. Each cycle lasted 10 min, ensuring sufficient averages for hourly and diurnal analysis. To maintain consistency, intervals of approximately 15 days were observed between measurement sessions.

The instrumentation used adhered to ISO 7726 (2006) [24] and ASHRAE guidelines [33] to ensure accuracy and reliability. Sensors were positioned at a height of 1.1 m, representing pedestrian-level conditions, and shielded from direct sunlight to minimize radiative interference. A stabilization period of 1.5 min was observed prior to data recording to allow the instruments to reach thermal equilibrium. Measurements included air temperature (AT), relative humidity (RH), wind speed (Wx), and Surface Temperature (T_{surf}). Wx calculations followed the methodology proposed by Andrade et al. (2011), combining maximum wind speed (MWS) and standard deviation (SD) using the formula $Wx = MWS + SD$. This approach, as proposed by Andrade et al. (2011) [34], defines Wx as a composite variable designed to evaluate the variability of wind conditions and their impact on thermal perception. Unlike the usual measurement of average wind speed, Wx incorporates fluctuations in wind patterns, capturing the dynamic nature of airflow and its influence on human comfort, taking account of the measurement occurring over 10 min at the same POI. This makes it particularly relevant for assessing how varying wind conditions, including gustiness,

contribute to pedestrian thermal sensations in urban spaces. T_{surf} measurements adhered to established guidelines from previous studies, such as those by Santamouris (2013) [22] and Nouri & Costa (2017) [20]. The instrumental devices used are listed in Table 2.

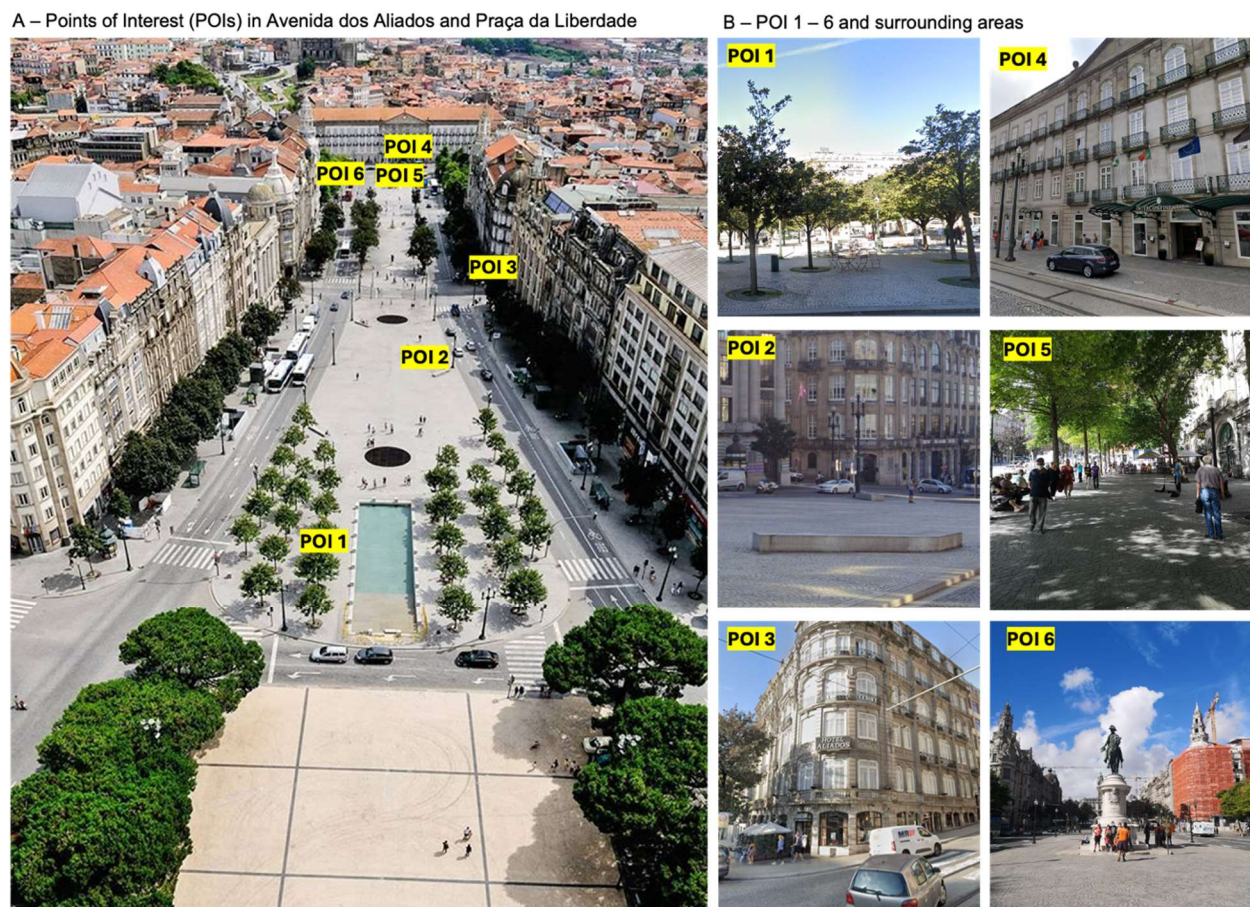


Figure 2. Instrumental locations in Avenida dos Aliados and Praça da Liberdade. Points of Interest (POIs) in Avenida dos Aliados and Praça da Liberdade (A) and POI 1–6 and surrounding areas (B). Source: Own elaboration, based on photos taken on Avenida dos Aliados and Praça da Liberdade.

The Sky View Factor (SVF) at each POI was assessed using Rayman Software (version 1.2) and confirmed through the grid method outlined by Martín-Vide et al. (2015) [35]. This analysis provided valuable insights into the spatial configuration of the study area and its impact on solar exposure. Particular attention was paid to environmental and climatic conditions during data collection.

Twelve measurement days were selected under stable atmospheric conditions, predominantly influenced by the Azores High. Daily forecasts from the Porto Pedras Rubras Station (located at the Francisco Sá Carneiro Airport) and evaluating the ECMWF (European Centre for Medium-Range Weather Forecasts) meteorological maps with the model-based forecasts available at IPMA (Portuguese Institute for the Sea and Atmosphere), along with their vertical profiles, were used to ensure favorable conditions for measurements. Notably, wind patterns during winter were more irregular (predominantly ESE-E), contrasting with the prevailing NNO winds observed during summer campaigns (Table 3).

Table 1. General descriptions of the Points of Interest in Avenida dos Aliados and Praça da Liberdade.

POI	Vegetation/Shelter Canopies/Water Conditions			Description
	Vegetation	Shelter Canopies	Water	
1	×	×	×	Existing linear plantation of evergreen Magnolia. It flowers between March and September. A walkable area with benches available for seating. There is a sprinkler system. A cobbled area.
2				Location in a cobbled area, without trees and close to a traffic lane. With a place to sit next to the measuring point.
3				Transitional area with buildings 12 m high and cobblestones on the pavement. There are no seating areas, and it is an area with heavy car traffic (with a junction).
4				Located in an open area (between Torre dos Clérigos and Rua de Santa Catarina), in front of the Intercontinental Hotel (12 m high). Transit area, no seats.
5	×	×		Large wooded area. Sturdy oak trees, large in size, with a rounded crown and a filling effect in the area. Flowering in May, with shady areas to linger. There are a few benches scattered around. The path is cobbled.
6				Location in a cobbled area without trees and close to a road. With a place to sit next to the measuring point. Central pavement area, a place normally used by tour guides to gather people for a visit.

Source: Own elaboration. Note: The × represents the presence of this type of condition.

Table 2. Instruments used for microclimatic measurements.

#	Instrument/Model Name	Measurement	Output Measurement Unit	Accuracy	Resolution
1	HANNAH THERMOHIGROMETER HI 9565© 	AT RH	°C %	± 0.5 °C (AT) 3% ±0.1	0.1 °C 0.1%
2	AIR FLOW METER PCE-007© 	AT W Flow	°C m/s --	±1 ±3% ±0.1 calculated from wind speed and surface	0.01 m/s
3	BENETECH GM550© 	ST	°C	1.5%	0.1 °C

Source: Own elaboration.

Table 3. The regression of the studied variables on Avenida dos Aliados and Praça da Liberdade—overall period, summer and winter season 2019–2020.

Day	AT (Max) (°C)	AT (Min) (°C)	RH (%) max	RH (%) min	Wind (MpH) Max Speed	Prevailing Wind Direction	Sea Level Pressure (Hg)	Type of Atmospheric Circulation	Nebulosity Conditions
14.07.2019	22	17	100	78	19	WNW–NW	1007.23	Depression regions centered west of mainland Portugal or of thermal origin over the Iberian Peninsula	Partly/Mostly cloudy
21.07.2019	24	13	100	69	22	NNW–NW	1011.20	Anticyclone located southwest or over the Azores Archipelago, sometimes extending ridge to the British Isles or with multiple cores, in action combined with thermal depression over the eastern part of the Iberian Peninsula	Fair
15.08.2019	24	15	100	57	24	NNW–NW	1012.19	Anticyclonic crest, associated with a high pressure center whose location oscillated in the Atlantic between the northeast and southwest regions of the Azores archipelago. Thermal depression, centered in the interior of the Iberian Peninsula	Fair
21.08.2019	28	17	94	47	22	NNW	1009.58	Anticyclonic crest, associated with a high pressure center whose location oscillated in the Atlantic between the northeast and southwest regions of the Azores archipelago. Thermal depression, centered in the interior of the Iberian Peninsula	Fair
24.12.2019 ¹	19	12	100	68	24	ESE–E	1018.50	Blocking anticyclone over the Iberian Peninsula, North Africa and Western Europe. East quadrant current	Fair
28.12.2019 ²	19	8	81	32	26	ESE–E	1019.49	Blocking anticyclone over the Iberian Peninsula, North Africa and Western Europe	Fair
23.02.2020 ³	20	5	100	49	9	WNW–NNW	1023.46	Anticyclone located in the Iberian Peninsula or in the Azores extending along the ridge towards the peninsula	Fair
11.07.2020	30	16	94	40	22	VAR (namely, NNW–NW–WNW)	1004.62	Anticyclone located over the British Isles. Approaching or passing through low activity frontal surfaces	Fair
05.08.2020	25	13	100	57	28	NNW–NW	1005.61	Anticyclone located in the region of the Azores archipelago, extending into the crest to the Bay of Biscay or to the British Isles. Thermal depression and/or inverted valley extending from northern Morocco to the Iberian Peninsula	Fair
08.08.2020	23	16	100	73	19	S	1010.57	Anticyclone located in the region of the Azores archipelago, extending into the crest to the Bay of Biscay or the British Isles	Fog/Mist
13.08.2020	22	13	100	68	19	NNW–WNW	1010.57	Anticyclone located over the Azores archipelago	Fair/Partly cloudy
21.08.2020	23	16	100	69	19	VAR (namely, SE, SSW, SW)	1013.54	Anticyclone located in the Azores archipelago, or south of it. Depressions centered to the west or on the Iberian Peninsula, with expression in altitude and/or approaching or passing frontal surfaces	Partly cloudy/Fair

Source: Own elaboration, based on IPMA (Portuguese Institute for Sea and Atmosphere data) Important events: ¹ Christmas Eve; ² S. Silvestre Running; ³ Carnival Sunday.

The methodology adopted for this study aligns closely with best practices established in previous research, such as the approach used by Nouri & Costa (2017) [20] for Rossio square in Lisbon, as well as studies by Alcoforado et al. (2009) [36], Oliveira et al. (2011) [37], and Rodríguez-Algeciras et al. (2016) [38]. These standardized procedures ensured consistency and reliability across all measurements, facilitating a robust analysis of microclimatic conditions in the study area.

This selection was crucial to analyze how different urban features—vegetation, shading, and open spaces—affect microclimatic variables, such as AT, RH, and wind patterns, in alignment with the study's objectives of understanding urban comfort diversity.

2.4. Subjective Approach

Considering that individuals exposed to different conditions at Avenida dos Aliados and Praça da Liberdade exhibit different thermal sensations and preferences, a parallel questionnaire survey was conducted during the field measurements based on a subjective approach.

Despite identical climatic and meteorological conditions, Nouri & Costa (2017) [20] pointed out that individuals tend to show certain behaviors:

- Exhibiting distinct thermal perceptions, considering the inherent subjectivity effects.
- Decreasing or increasing in their desire to stay in a place due to environmental stimuli.
- If there are no places on the street/venue that they find thermally comfortable, deciding to look for other places to stay.

Considering these three assumptions, this subjective approach aimed to conduct an analysis based on decisions and adjustments to thermal comfort between different points on Avenida dos Aliados and Praça da Liberdade. The analysis was carried out for each of the 6 points, considering a radius of 150 m, to observe the behavior of the individuals.

These analyses are related to the mapping of the behavior of 123 pedestrians within the study areas (based on their behavior within the Avenue and, additionally, by marking circular areas in blue and red, indicating what they considered “cooler” and “warmer”, respectively—Appendix A). This perception exercise with pedestrians took place at 9:00 GMT + 00 and 17:00 GMT + 00 on each of the 8 days of the measurement campaign. The opinions of 123 people were recorded (45 in the summer of 2019, 41 in the winter of 2019–2020, and 37 in the summer of 2020). This analysis followed other work carried out by the team in the study area [10,11].

The sample of 123 participants was selected using a convenience sampling method, based on the number of individuals present at each POI during the survey time. Participants were included if they were actively using the space and willing to participate in the study. While not a probabilistic sample, efforts were made to ensure diversity in gender and age groups. A survey was conducted on individuals who had previously traversed the entire area of Avenida dos Aliados and Praça da Liberdade, after being challenged to do so. Information was collected from each participant by a third researcher who recorded information on socio-demographic characteristics (e.g., biological sex, age, whether accompanied).

In terms of the sample, there was an equal distribution between male and female participants (Table 4). In terms of age, the 45–64 and 65+ age groups were the most represented in all periods, indicating the presence of older people in the places of stay, especially in summer 2019 and winter 2019–2020. Most of the participants were accompanied during the interviews. The distribution of interviews across the different Points of Interest (POIs) was relatively balanced, with POI 6 being the most relevant in all time periods. In addition, the interviews took place mainly in the afternoon, especially between 15:00 and 17:00, suggesting a preference for this time for activities related to recreation and leisure.

Table 4. Sociodemographic characteristics of mental maps of participants.

Characteristics	Total (N = 123)	Summer 2019 (N = 45)	Winter 2019–2020 (N = 41)	Summer 2020 (N = 37)
<i>Gender</i>				
Male	61	20	23	18
Female	62	25	18	19
<i>Age</i>				
15–24	21	5	6	10
25–44	25	9	8	8
45–64	34	12	10	12
65 and more	43	19	17	7
<i>Accompanied</i>				
Yes	79	28	23	28
No	44	17	18	9
<i>Interview POI</i>				
POI 1	26	10	8	8
POI 2	10	3	4	3
POI 3	12	4	4	4
POI 4	16	5	6	5
POI 5	24	11	8	5
POI 6	35	12	11	12
<i>Hour of interview (GTM + 00)</i>				
10:00–11:00	25	10	8	7
11:00–12:00	19	7	6	6
14:00–15:00	19	7	7	5
15:00–16:00	26	9	9	8
16:00–17:00	34	12	11	11

Source: Own elaboration, based on 123 mental map interviews.

After all the analysis, we created the thermal sensation map, integrating subjective pedestrian feedback to represent perceived thermal comfort across the study area. This process included the following steps:

- (i) Pedestrian thermal perceptions were gathered through surveys conducted at each Point of Interest (POI) during the measurement campaigns. Participants were asked to indicate their perceived thermal comfort using a simplified binary scale (“hottest” and “coolest” areas) to align with the ease of mapping broader trends in pedestrian behavior. These responses were recorded alongside the specific locations where individuals reported their perceptions, allowing spatial variability to be captured.
- (ii) The thermal sensation map was generated using a Geographic Information System (GIS) framework. The binary thermal sensation scale was mapped across the study area using interpolation technique, namely the Inverse Distance Weighting (IDW), to visualize spatial patterns of perceived comfort. Areas marked “high” indicated zones where most participants reported “warmer” thermal sensations, while “low” zones represented areas with “cooler” sensation.

Although the sample size is relatively small, it captures a significant cross-section of urban space users, providing valuable insights into the interaction between environmental conditions and user behavior.

Ethical review and approval were not required for this study. The project was approved in September 2017 (funded by FCT Portugal and approved with reference ICS-120/2017). The project did not fall within the scope of the Ethics Committee, and therefore, the approval of the Ethics Committee was not required. Informed consent was obtained from all subjects involved in the study upon completion of the questionnaire survey.

This analysis was accompanied by an observation method that counted the behavior at the six analysis points (with an analysis of the number of people standing or sitting).

3. Results

3.1. Objective Dimension—Evaluation of Comfort Levels Based on Microclimatic Measurements

Diurnal microclimatic measurements were conducted on various days for six Points of Interest (POIs), between 1 and 6. Figure 3 reveals the average values of microclimatic measurements for the summer months of 2019–2020. POI 3 recorded the highest AT between 10:00 GMT + 00 and 14:00 GMT + 00, while in the period between 15:00 GMT + 00 and 17:00 GMT + 00, POI 1, 2, and 6 had the highest AT values (Figure 3A). POI 4 and 5 consistently had the lowest AT due to exposure to solar radiation and daytime shadow.

Humidity patterns (RH—in %) showed the well-known strong negative correlation with AT during the day. Specifically, it was observed that POIs with lower AT during the initial cycles corresponded to those with higher RH (%). Furthermore, changes in the trend between these two microclimatic variables illustrated a strong relationship between them (Figure 3B).

Considering the possible influences of vegetation and water sources at the respective POIs, it was confirmed that it did not have a perceptible effect on the surrounding RH (%) levels or AT, except for what occurred at POI 5. Therefore, these results confirmed that spot tree planting is less effective in evaporative cooling than cluster planting [39].

Regarding wind patterns, the obtained data were similar to the a priori simulated ones. As in the previous CFD simulations, only POI 2, 3, and 4 had the potential to form wind tunnels (Figure 3C). Compared to other locations, POI 2 showed that, during the summer, wind speed is more significant, although it maintains a moderate speed. By late afternoon (between 16:00 GMT + 00 and 17:00 GMT + 00), this area exceeded the average speed of $\geq 2.0 \text{ m}\cdot\text{s}^{-1}$.

T_{surf} is strongly dependent on solar radiation. Areas exposed to solar radiation corresponded to those with higher T_{surf} (Figure 3D). Specifically, from 12:00 GMT + 00 until 17:00 GMT + 00, POI 2 and 5 had, on average, $T_{\text{surf}} \geq 38.0 \text{ }^{\circ}\text{C}$.

Some locations on Avenida dos Aliados and Praça da Liberdade are more pleasurable to visit and stay during the summer. The presence of shade helps enhance the thermal comfort levels, which is why many entertainment and recreational activities take place at POI 5 in Praça da Liberdade during the summer, unlike POI 6, which becomes a passing-through spot, mainly to take photographs and observe the Monument to D. Pedro IV, especially in the late afternoon.

During the winter, thermal patterns were different (Figure 4), particularly regarding (i) the records of AT and T_{surf} during the daytime, as AT and T_{surf} increased until around 14:30 GMT + 00; (ii) the northern section of Avenida experiencing greater exposure to solar radiation, contributing to higher values of AT and T_{surf} ; (iii) the southern border section of Praça da Liberdade recording lower values of AT and T_{surf} during the day, and RH (%) values tending to be higher for much of the day.

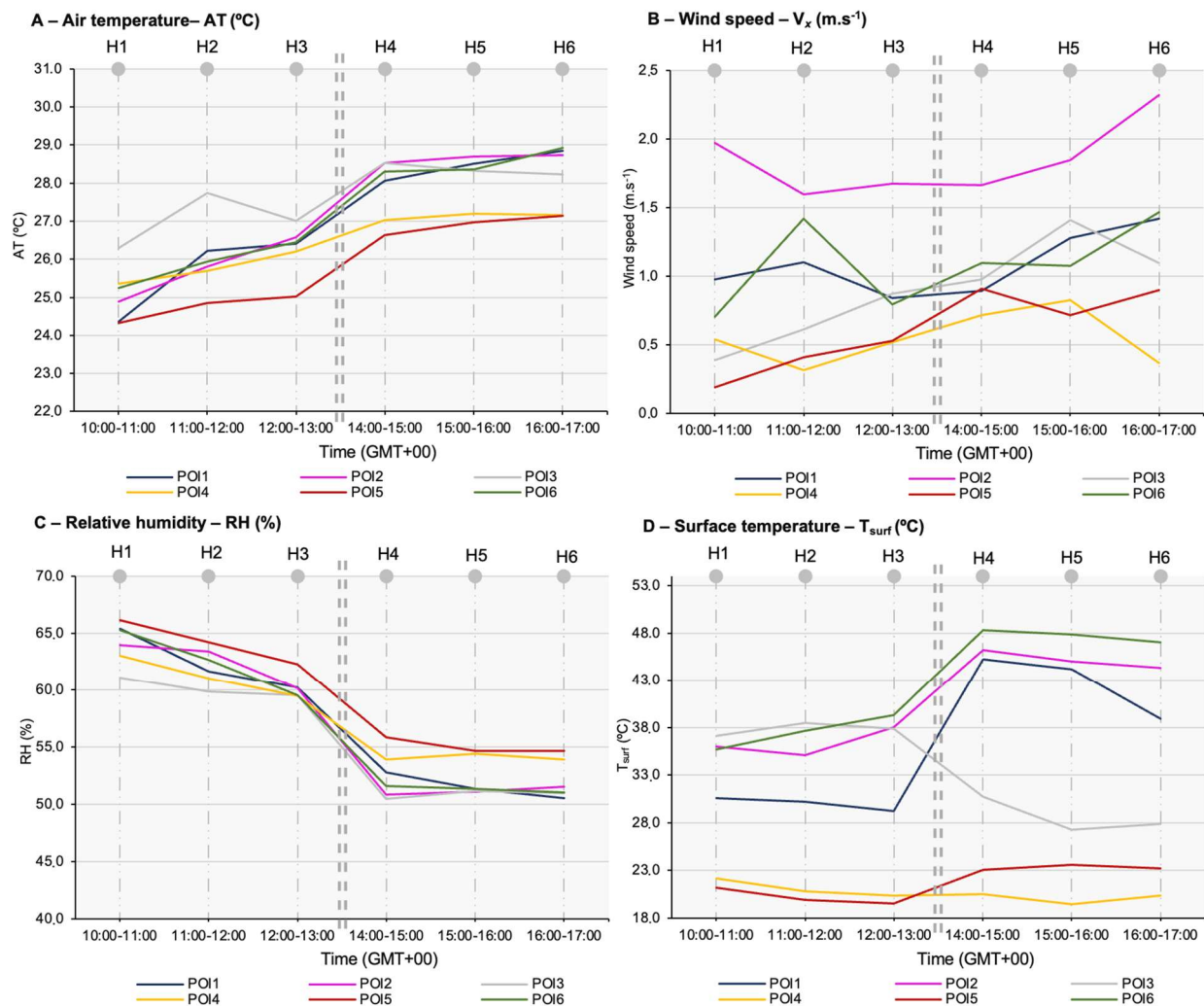


Figure 3. Average results obtained from meteorological instruments between 10:00 AM and 1:00 PM and between 2:00 PM and 5:00 PM with a break from 1:00 PM to 2:00 PM (GMT + 00) on Avenida dos Aliados and Praça da Liberdade during the summer of 2019 and 2020. (A) Air Temperature—(AT—°C); (B) Wind Speed (V_x —m.s⁻¹); (C) Relative Humidity (RH—%); (D) Surface Temperature (T_{surf} —°C). Source: Own elaboration, based on campaign measurements carried out on Avenida dos Aliados and Praça da Liberdade.

Similar to the summer period, the intermediate section of Avenida dos Aliados (POI 2) registered higher wind speeds (averaging over 2.5 m.s⁻¹ between 12:00 GMT + 00 and 13:00 GMT + 00). The initial section (to the north) of Avenida dos Aliados can be considered more pleasant for stay during the winter. Nevertheless, the number of days analyzed was not sufficient to suggest specific areas for individuals to stay or pass through during the winter.

With a focus on microclimatic characteristics, Table 5 records the regression value (r) between two variables at each location, and the average values of r were identified for all POIs (designated as $\bar{r}$). Regarding the variables used, (1) the linear regression trend to identify a positive or negative influence between variable pairs (the +/− values of the Pearson correlation coefficient signal, respectively, positive/negative influence); (2) the p -value (p) values to determine the significance level of each $\bar{r}$, ensuring that $p \leq 0.05$; and (3) establishing the overall strength of the relationship for each set of variables.

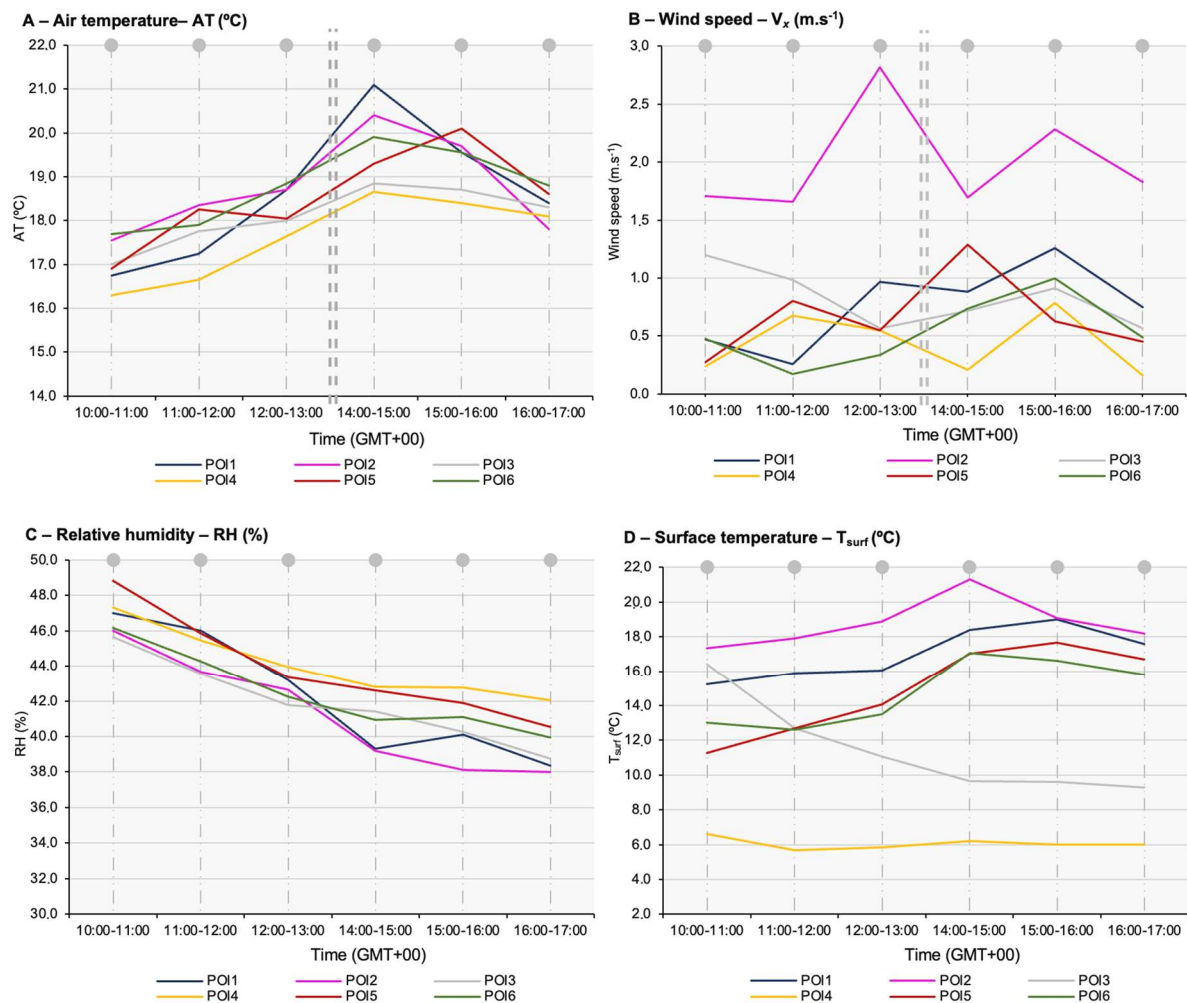


Figure 4. Average results obtained from meteorological instruments between 10:00 AM and 1:00 PM and between 2:00 PM and 5:00 PM with a break from 1:00 PM to 2:00 PM (GMT + 00) on Avenida dos Aliados and Praça da Liberdade during the winter of 2019 and 2020. (A) Air Temperature—(AT—°C); (B) Wind Speed (V_x — $m \cdot s^{-1}$); (C) Relative Humidity (RH—%); (D) Surface Temperature (T_{surf} —°C). Source: Own elaboration, based on campaign measurements carried out on Avenida dos Aliados and Praça da Liberdade.

Table 5. Regression of the studied variables on Avenida dos Aliados and Praça da Liberdade—overall period, summer and winter season 2019–2020.

Microclimatic Variables (Average)	Analysis Period	POI						+/-
		POI 1	POI 2	POI 3	POI 4	POI 5	POI 6	
AT vs. RH (%)	Global	$r = 0.924$	$r = 0.841$	$r = 0.906$	$r = 0.974$	$r = 0.939$	$r = 0.741$	0.887 -- $p < 0.001$
	Summer	$r = 0.985$	$r = 0.985$	$r = 0.885$	$r = 0.992$	$r = 0.995$	$r = 0.528$	0.895 -- $p < 0.001$
	Winter	$r = 0.863$	$r = 0.697$	$r = 0.926$	$r = 0.955$	$r = 0.882$	$r = 0.954$	0.880 -- $p < 0.001$

Table 5. Cont.

Microclimatic Variables (Average)	Analysis Period	POI							+/-
		POI 1	POI 2	POI 3	POI 4	POI 5	POI 6		
AT vs. W_{speed}	Global	$r =$ 0.640	$r =$ 0.179	$r =$ 0.736	$r =$ 0.276	$r =$ 0.684	$r =$ 0.582	0.516 -- $p = 0.556$	-
								0.589 -- $p = 0.431$	
	Summer	$r =$ 0.580	$r =$ 0.288	$r =$ 0.767	$r =$ 0.462	$r =$ 0.933	$r =$ 0.503	0.444 -- $p = 0.771$	
	Winter	$r =$ 0.700	$r =$ 0.070	$r =$ 0.706	$r =$ 0.090	$r =$ 0.435	$r =$ 0.661		
AT vs. G_{rad}	Global	$r =$ 0.662	$r =$ 0.696	$r =$ 0.751	$r =$ 0.644	$r =$ 0.386	$r =$ 0.396	0.589 -- $p < 0.001$	+
								0.737 -- $p < 0.001$	
	Summer	$r =$ 0.887	$r =$ 0.564	$r =$ 0.662	$r =$ 0.968	$r =$ 0.749	$r =$ 0.594	0.440 -- $p < 0.001$	
	Winter	$r =$ 0.436	$r =$ 0.827	$r =$ 0.839	$r =$ 0.320	$r =$ 0.023	$r =$ 0.197		
AT vs. T_{surf}	Global	$r =$ 0.528	$r =$ 0.948	$r =$ 0.862	$r =$ 0.434	$r =$ 0.914	$r =$ 0.961	0.774 -- $p < 0.05$	+
								0.862 -- $p < 0.05$	
	Summer	$r =$ 0.799	$r =$ 0.957	$r =$ 0.755	$r =$ 0.813	$r =$ 0.873	$r =$ 0.976	0.686 -- $p < 0.05$	
	Winter	$r =$ 0.257	$r =$ 0.939	$r =$ 0.968	$r =$ 0.054	$r =$ 0.954	$r =$ 0.946		
T_{surf} vs. w_{speed}	Global	$r =$ 0.518	$r =$ 0.164	$r =$ 0.815	$r =$ 0.581	$r =$ 0.551	$r =$ 0.606	0.539 -- $p < 0.05$	-
								0.499 -- $p < 0.05$	
	Summer	$r =$ 0.351	$r =$ 0.298	$r =$ 0.846	$r =$ 0.379	$r =$ 0.713	$r =$ 0.406	0.579 -- $p < 0.05$	
	Winter	$r =$ 0.685	$r =$ 0.030	$r =$ 0.784	$r =$ 0.782	$r =$ 0.388	$r =$ 0.806		
RH (%) vs. w_{speed}	Global	$r =$ 0.717	$r =$ 0.314	$r =$ 0.813	$r =$ 0.229	$r =$ 0.621	$r =$ 0.531	0.537 -- $p = 0.351$	-
								0.615 -- $p = 0.426$	
	Summer	$r =$ 0.575	$r =$ 0.321	$r =$ 0.835	$r =$ 0.433	$r =$ 0.943	$r =$ 0.581	0.460 -- $p = 0.226$	
	Winter	$r =$ 0.858	$r =$ 0.307	$r =$ 0.790	$r =$ 0.025	$r =$ 0.299	$r =$ 0.481		

Source: Own elaboration, based on campaign measurements carried out on Avenida dos Aliados and Praça da Liberdade. Notes: r (regression values); $\bar{r}_p$ (mean regression in all POIs and p -value); + / - (positive and negative influence). Regression strength: outstanding (1.000–0.900); very strong (0.899–0.700); strong (0.699–0.600); average (0.599–0.500); weak (0.499–0.300); very weak (0.299–0.100); nugatory (≤ 0.099).

The various coefficient results demonstrated that, on the one hand, there is an intrinsic balance between microclimate elements, and, on the other hand, urban structures (building configuration and distribution and arrangement of vegetation) influence these relationships

between spaces, both with direct effects in the study area and with direct and/or indirect effects in adjacent areas. As expected, AT and RH (%) showed a very strong correlation ($\bar{r} = -0.887$; $p \leq 0.001$).

In the early morning, because of the cooler air being close to saturation, AT and RH (%) recorded an “excellent” average negative coefficient at all POIs. These results are in line with other studies conducted for other cities, such as Bloomington (Indiana, USA), Tel-Aviv (Israel), Genoa, Milan, Rome (Italy), and Lisbon (Portugal—e.g., Souch & Souch, 1993 [40]; Shashua-Bar & Hoffman, 2000 [39]; Perini & Magliocco, 2014 [41]; Nouri & Costa, 2017b [20]). Similarly, a strong relationship between AT and T_{surf} was identified in the overall analysis and during the summer season. This relationship is attributed to the sensible heat released into the atmosphere when T_{surf} exceeds AT [22,42]. In contrast, the relationship between wind patterns and other microclimatic variables revealed the following characteristics:

- Wind patterns generally have a weak effect among other variables for all observation points.
- The weakness in the statistical relationship between the set of variables is corroborated based on higher p -values (e.g., AT vs. W_{speed}); note that nevertheless, POIs 1 and 3 show stronger correlations, because of the r values.

It should be noted regarding wind speed that values between 1.0 and 2.0 $\text{m}\cdot\text{s}^{-1}$ demonstrate, during the summer period, a strong influence on thermal sensation when the pedestrian is under the direct solar radiation. They also reveal a considerably weak effect in shaded conditions. During winter, the effect of higher wind speed accentuates discomfort in any of the locations, whether under the influence of direct solar radiation or not. Despite being in direct exposure to solar radiation, POI 2 showed a higher wind intensity in both seasons.

3.2. Subjective Dimension—An Analysis Based on Decisions and Adjustments for Thermal Comfort

The perception of thermal comfort varies significantly between different places in the square/avenue. The perception of hot and cool areas is shown in Figure 5 through mental maps drawn by individuals. These results have been superimposed to highlight the seasonal differences (summer 2019, winter 2019–2020, and summer 2020). The detected clues did not always coincide with the results obtained from the meteorological instruments used in the microclimatic measurements. The people who participated in the creation of the mental maps maintained the following:

- (i) The central areas of Avenida dos Aliados are considered warmer;
- (ii) The areas south of Avenida dos Aliados and Praça da Liberdade were identified as cooler points.

Figure 6 shows the number of pedestrians at the Points of Interest (POIs) where microclimatic measurements were taken.

This count differentiated between pedestrians who were standing or sitting. The highest number of pedestrians was located south of Avenida dos Aliados and Praça da Liberdade, specifically at POIs 5 and 6. POI 4 and 5 were the areas with the highest pedestrian traffic during the winter of 2019–2020. In some of the POIs, people took the opportunity to sit down. This differentiation extends throughout the intraday period, with a reduction in pedestrians in different points of Avenida dos Aliados during the day and a significant increase between 16:00 GMT + 00 and 17:00 GMT + 00. POI 5 proves to be crucial during the day due to the shading effect caused by the tree canopy, resonating with the documented peaking phenomenon in public spaces by Pushkarev & Zupan (1975) [43], suggesting they were least used in the morning, most used near noon, and moderate

in the afternoon. This is also corroborated by Gehl's studies [2], which highlight how microclimatic factors influence the permanence and movement of people in urban areas.

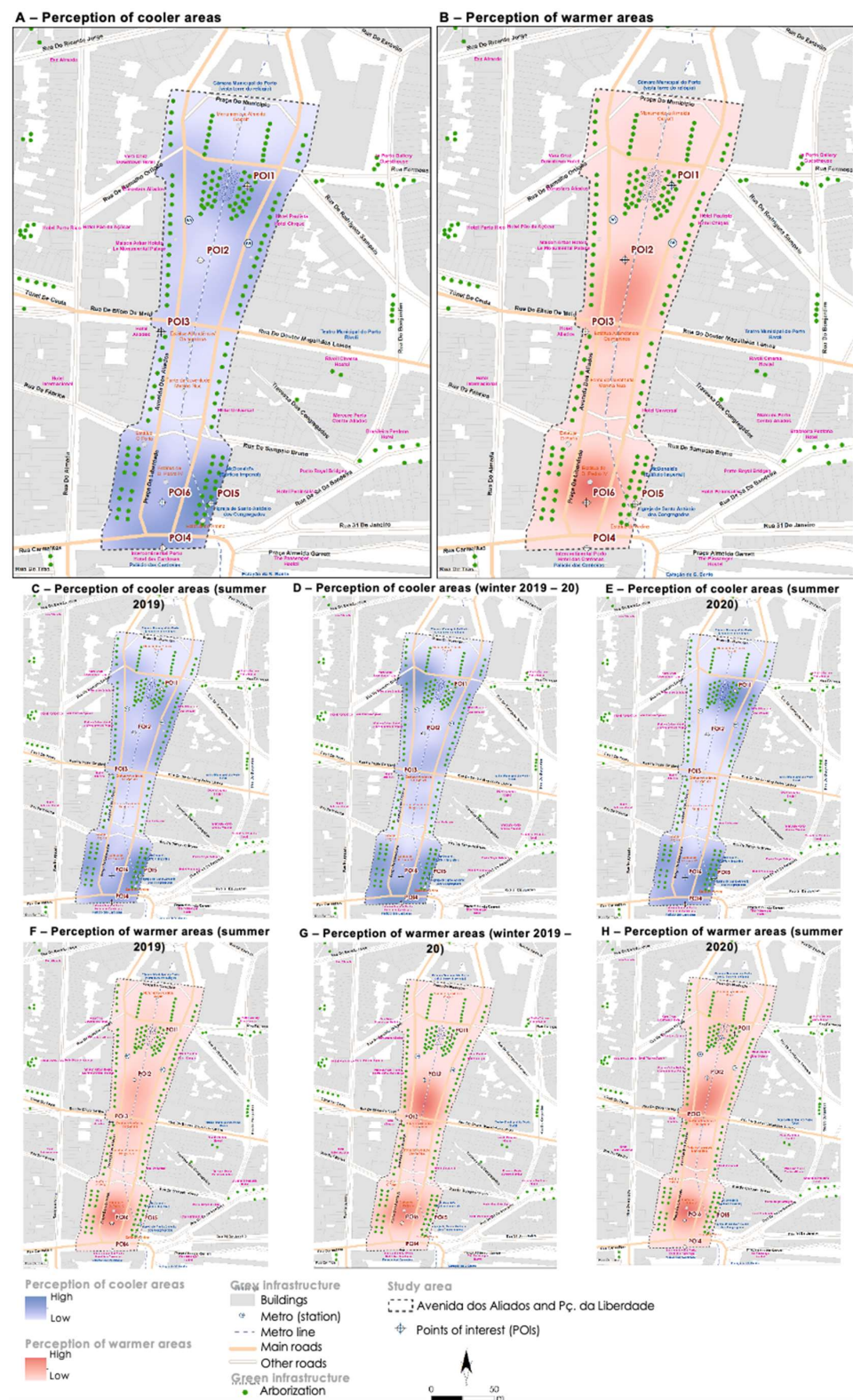


Figure 5. Thermal sensation map in Avenida dos Aliados and Praça da Liberdade. (A) Perception of cooler areas; (B) perception of warmer areas; (C–E) perception of cooler areas in summer 2019, winter 2019–2020, and summer 2020, respectively; (F–H) perception of warmer areas in summer 2019, winter 2019–2020, and summer 2020, respectively. Source: own elaboration, based on campaign measurements carried out on Avenida dos Aliados and Praça da Liberdade.

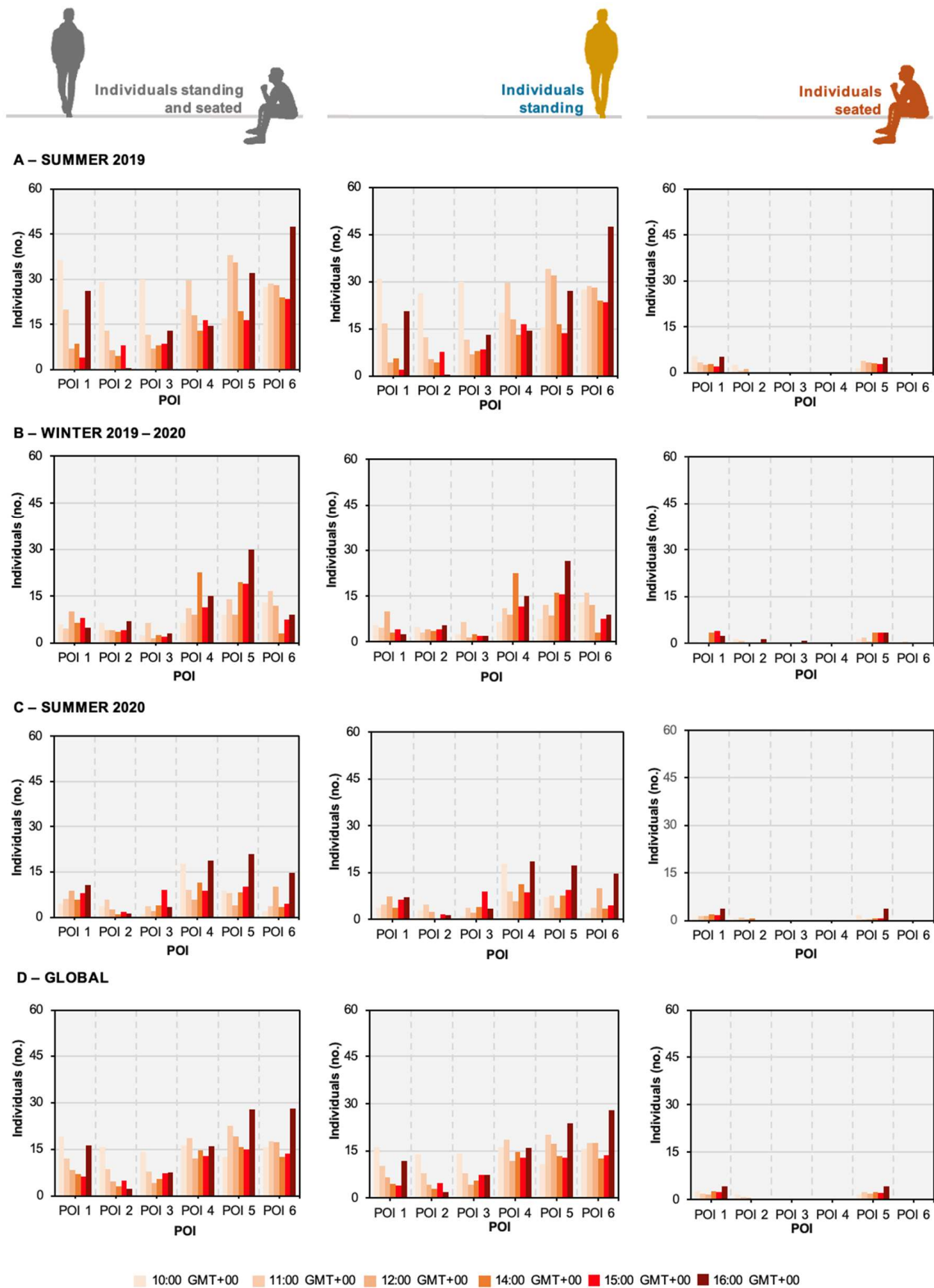


Figure 6. Pedestrian counts (average pedestrian) at microclimate monitoring sites and questionnaire survey sites. (A) Summer 2019; (B) winter 2019–2020; (C) summer 2020; and (D) total. Source: own elaboration, based on pedestrian counts by observation method.

These results indicate that many pedestrians in all areas of Avenida dos Aliados and Praça da Liberdade made a psychological decision to expose themselves to such stimuli for defined periods of time, based on the thermal comfort at the time of the survey. There was a greater relationship between the time spent in a particular POI and the higher level of comfort. The results indicate that a significant proportion of pedestrians made psychological decisions based on the thermal comfort of the moment. These results are in line with the studies by Nikolopoulou & Steemers (2003) [44], which address how the subjective perception of thermal comfort influences the choice to stay in certain locations within public spaces.

4. Discussion and Conclusions

The research highlights the pronounced microclimatic variability that characterizes Avenida dos Aliados and Praça da Liberdade, demonstrating the complex interplay between urban structures, solar exposure, and wind patterns. Seasonal differences have a significant impact on thermal comfort, with discernible patterns in both summer and winter. Shaded areas, especially within the Praça da Liberdade, emerge as preferred locations during warmer seasons, indicating the influence of environmental elements on pedestrian preferences. During winter, thermal patterns differ significantly, with lower AT and ST observed, particularly in shaded or northern areas. Pedestrian behavior adapts accordingly, with a notable preference for sunlit locations, such as the northern section of Avenida dos Aliados, which exhibited higher T_{surf} values during midday due to greater solar exposure. Conversely, southern areas of Praça da Liberdade were less frequented due to cooler conditions and higher RH, highlighting the role of microclimatic variability in shaping user choices.

A notable finding is the discrepancy between instrumental measurements and pedestrian-generated mental maps, emphasizing the subjective nature of thermal comfort perception. Individuals often prioritize shaded areas, deviating from the influence of purely meteorological conditions. Indeed, a previous study conducted by Vidal et al. (2022) [45] found that individuals prefer to be close to shaded areas, particularly trees, regardless of whether it is sunny or not. For instance, the popularity of shaded areas in summer and sunlit spots in winter demonstrates the importance of designing spaces that encourage prolonged stays, as highlighted by Gehl's emphasis on integrating microclimatic factors into public space design [2]. This observation underscores the importance of considering both objective climatic data and individual perceptions and preferences when evaluating the comfort of urban spaces. As Berger & Luckmann (2016) [46] suggested in their sociological theory of the "social construction of reality", individuals interpret and define their reality based on their subjective experiences. In this context, individuals perceiving different thermal sensations despite identical meteorological conditions illustrate how personal experiences influence perceptions of comfort and discomfort in urban settings. This finding also supports Henri Lefebvre's thesis of "perceived space" against "conceived space". Perceived space is how people subjectively experience and interpret space, whereas conceptualized space refers to the objective, measured characteristics of space. The disparity between subjective perceptions and objective measurements reveals how people's mental maps and subjective experiences shape their spatial perceptions and decisions in urban environments [47]. While objective data identified cooler areas with vegetation as thermally comfortable, subjective preferences revealed a stronger inclination for sunlit locations in winter. This highlights the need for urban designs that address both measurable climatic conditions and human experiential factors.

Pedestrians exhibit adaptive behavior by strategically selecting certain locations based on their perceived thermal comfort. The higher pedestrian influx in shaded areas suggests

the critical role of environmental features in shaping movement and dwell decisions. This behavioral aspect adds a nuanced layer to the understanding of urban microclimates, highlighting the need for a holistic approach that integrates both climatic data and human experience. Also, individuals' tendency to adjust their stay in a location based on environmental stimuli is like the concept of "tactical urbanism" in sociology, referring to how people actively and adaptively interact with their environment, modifying or redefining the use of urban places in response to immediate demands or preferences. When people choose to seek alternative locations or relocate due to discomfort, it demonstrates their agency in navigating and negotiating urban environments to meet their comfort requirements [48]. The integration of strategies that advance sustainability, such as the incorporation of vegetation to enhance thermal comfort and environmental quality, empowers urban planners to create spaces that not only meet present-day needs but are also equipped to address the future challenges posed by climate change. As proposed by authors such as Nouri & Costa (2017) [13], sustainable placemaking should be a primary objective in contemporary urban planning.

The results provide information for optimizing public spaces to improve thermal comfort. Consideration of elements such as vegetation, shading structures, and spatial configurations will be essential in creating urban environments that meet the diverse needs and preferences of pedestrians. Additionally, it will be crucial in a climate change scenario to acknowledge the seasonal variations in thermal comfort and usage patterns by designing rooms that can withstand both summer and winter temperatures, such as using adaptive shade components or wind barriers. This can be complemented through the identification and establishing of key spots in public settings that provide increased comfort levels and improve the overall user experience. These nodes can be outfitted with shade components, sitting configurations, and landscaping to encourage extended interaction. Most importantly, and sometimes underestimated in urban planning, is the need to design streets and public spaces with pedestrian comfort in mind to encourage active use. Putting pedestrian-friendly elements first, such as shaded walkways, lounging areas, and windbreaks, can help to attract and retain foot traffic all day [2,49,50]. It is important to consider the potential of urban spaces as sustainable refuges within a larger urban environment, as postulated by Foucault's 'heterotopias' paradox [51].

In fact, the relationships between key microclimatic variables—such as AT, RH, and T_{surf} —and behavioral patterns reveal actionable insights for urban planning:

1. The strong correlation between AT and T_{surf} emphasizes the need for material selection in urban surfaces. Surfaces with high thermal emissivity should be prioritized in winter to retain heat, while materials with low heat absorption are recommended for summer.
2. The critical role of greenery in mitigating heat during summer and providing aesthetic value in winter. Strategically placed deciduous trees could offer shade in summer while allowing sunlight in winter, supporting year-round usability.
3. While wind provided cooling relief in summer, its intensification during winter increased discomfort, particularly in open areas like POI 6. The inclusion of vegetation barriers or architectural windbreaks could mitigate this effect, ensuring more pleasant winter conditions.
4. The preference for shaded areas in summer and sunlit zones in winter suggests the need for modular, seasonally adaptive spaces. Features such as retractable shading structures and flexible seating arrangements can address these dynamic requirements.

Despite this, the study's narrow focus on specific seasons (summer and winter of 2019–2020) may not fully encompass long-term climatic variations or exceptional events that could potentially influence pedestrian behavior and thermal comfort. Additionally, the

study's emphasis on microclimatic factors and thermal perception may have overlooked other potential influences, such as air quality, noise, and socioeconomic factors, which could also affect pedestrian behavior. Encouraging collaboration among urban planners, architects, environmental scientists, and sociologists to create holistic designs that consider microclimate variables, behavioral elements, and social requirements, may result in inclusive and flexible urban areas. Future urban planning efforts in Porto and similar cities should (1) incorporate seasonally responsive elements such as deciduous vegetation, windbreaks, and solar-absorbing materials; (2) design flexible public spaces with movable seating and adjustable shading to accommodate both summer and winter preferences; and (3) engage local communities in participatory design processes to align urban development with user needs and perceptions.

Despite the advancements in the study, certain limitations highlight the need for further assessment:

- (1) Expanding temporal scope—a broader temporal scope is needed to capture year-round variations and extreme weather events, which can significantly affect pedestrian behavior and the usability of public spaces. Future research should include longitudinal assessments over multiple years to better understand the adaptability of urban spaces under different climate scenarios, particularly in the context of climate change.
- (2) Incorporating additional variables—the emphasis on microclimatic factors and thermal perception, while essential, overlooks other critical influences, such as air quality, noise, and socioeconomic conditions. In future studies, these variables would provide a more holistic understanding of the factors shaping urban space use and enable the development of urban design strategies that address multiple dimensions of the urban experience.

Author Contributions: Conceptualization, H.S.L., P.C.R., D.G.V., V.R., L.T.S. and J.M.-V.; methodology, H.S.L.; software, H.S.L.; validation, H.S.L., P.C.R., D.G.V., V.R., L.T.S. and J.M.-V.; formal analysis, H.S.L., P.C.R., D.G.V., V.R., L.T.S. and J.M.-V.; investigation, H.S.L. and D.G.V.; resources, H.S.L., P.C.R., D.G.V., V.R., L.T.S. and J.M.-V.; data curation, H.S.L., P.C.R., D.G.V., V.R., L.T.S. and J.M.-V.; writing—original draft preparation, H.S.L., P.C.R., D.G.V., V.R., L.T.S. and J.M.-V.; writing—review and editing, H.S.L., P.C.R., D.G.V., V.R., L.T.S. and J.M.-V.; visualization, H.S.L., P.C.R., D.G.V., V.R., L.T.S. and J.M.-V.; supervision, H.S.L., P.C.R., D.G.V., V.R., L.T.S. and J.M.-V.; project administration, H.S.L., P.C.R., D.G.V., V.R., L.T.S. and J.M.-V.; funding acquisition, H.S.L., P.C.R. and J.M.-V. All authors have read and agreed to the published version of the manuscript.

Funding: This publication was supported by the Multiannual Funding of the Laboratory of Landscapes, Heritage and Territory (Lab2PT), Ref. UIP/04509/2020, financed by national funds (PIDDAC) through FCT/Q3 MCTES.

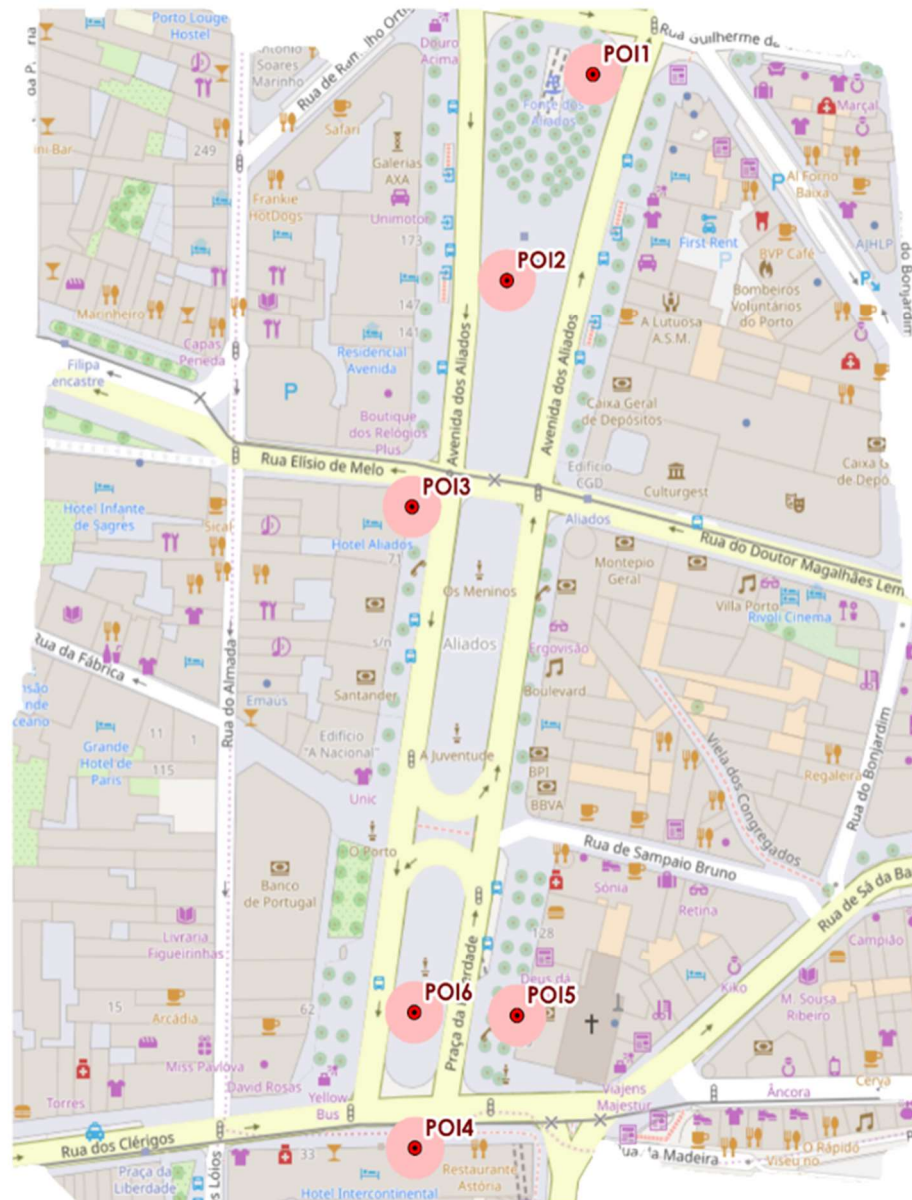
Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Perceptions of hot and cool areas on Avenida dos Aliados (*Aliados Avenue*) and Praça da Liberdade (*Liberdade Square*)

Based on your experience at Avenida dos Aliados (Aliados Avenue) and Praça da Liberdade (Liberdade Square), mark in the Figure below the place that you consider hottest with an **X** (or a red circle ●) and an **O** (or a blue circle ●) the place that you consider coolest.



Thank you very much. ☺

References

1. Whyte, W.H. *The Social Life of Small Urban Spaces*; Conservation Foundation: Washington, DC, USA, 1980.
2. Gehl, J. *Life Between Buildings*; Van Nostrand Reinhold: New York, NY, USA, 1987.
3. Carmona, M. The place-shaping continuum: A theory of urban design process. *J. Urban Des.* **2014**, *19*, 2–36. [[CrossRef](#)]

4. Carmona, M. Place value: Place quality and its impact on health, social, economic and environmental outcomes. *J. Urban Des.* **2019**, *24*, 1–48. [[CrossRef](#)]
5. Wesener, A.; Fox-Kämper, R.; Sondermann, M.; Münderlein, D. Placemaking in action: Factors that support or obstruct the development of urban community gardens. *Sustainability* **2020**, *12*, 657. [[CrossRef](#)]
6. Palazzo, E. Design for change: An adaptive approach to urban places in transformation. In *Placemaking Fundamentals for the Built Environment*; Palgrave Macmillan: Singapore, 2020; pp. 129–156.
7. Mahmoud, I.H. Public Spaces and Placemaking Approach: The Implementation Strategies. In *Placemaking for Green Urban Regeneration*; Springer: Berlin/Heidelberg, Germany, 2022; pp. 9–28.
8. Amirzadeh, M.; Sharifi, A. The evolutionary path of place making: From late twentieth century to post-pandemic cities. *Land Use Policy* **2024**, *141*, 107124. [[CrossRef](#)]
9. Bögel, P.M.; Augenstein, K.; Levin-Keitel, M.; Upham, P. An interdisciplinary perspective on scaling in transitions: Connecting actors and space. *Environ. Innov. Soc. Transit.* **2022**, *42*, 170–183. [[CrossRef](#)]
10. Lopes, H.S.; Remoaldo, P.C.; Ribeiro, V.; Martin-Vide, J. Perceptions of human thermal comfort in an urban tourism destination—A case study of Porto (Portugal). *Build. Environ.* **2021**, *205*, 108246. [[CrossRef](#)]
11. Lopes, H.S.; Remoaldo, P.C.; Ribeiro, V.; Martin-Vide, J. Pathways for adapting tourism to climate change in an urban destination—Evidences based on thermal conditions for the Porto Metropolitan Area (Portugal). *J. Environ. Manag.* **2022**, *315*, 115161. [[CrossRef](#)]
12. Costa, J.P. *Urbanismo e Adaptação às Alterações Climáticas: As Frentes de Água*; Livros Horizonte: Lisbon, Portugal, 2013.
13. Santos Nouri, A.; Costa, J.P. Placemaking and climate change adaptation: New qualitative and quantitative considerations for the “Place Diagram”. *J. Urban. Int. Res. Placemak. Urban Sustain.* **2017**, *10*, 356–382. [[CrossRef](#)]
14. Monteiro, A.; Madureira, H.; Fonseca, L.; Gonçalves, P. *METROCLIMA: Plano Metropolitano de Adaptação às Alterações Climáticas—Área Metropolitana do Porto*; Área Metropolitana do Porto: Porto, Portugal, 2018.
15. Monteiro, A.; Madureira, H.; Fonseca, L.; Velho, S. *Suporte Biofísico e Ambiente—Clima e Ambiente Urbano (Relatório de Caracterização e Diagnóstico)—2ª Revisão do PDM do Porto*; Departamento Municipal de Planeamento Urbano—Câmara Municipal do Porto: Porto, Portugal, 2018.
16. Madureira, H.; Monteiro, A.; Cruz, S. Where to go or where not to go—A method for advising communities during extreme temperatures. *Climate* **2021**, *9*, 49. [[CrossRef](#)]
17. Olgyay, V. *Design with Climate: Bioclimatic Approach to Architectural Regionalism*; Princeton University Press: Princeton, NJ, USA, 2015.
18. Matzarakis, A.; Amelung, B. Physiological equivalent temperature as indicator for impacts of climate change on thermal comfort of humans. In *Seasonal Forecasts, Climatic Change and Human Health: Health and Climate*; Springer: Berlin/Heidelberg, Germany, 2008; pp. 161–172.
19. Erell, E.; Pearlmutter, D.; Williamson, T. *Urban Microclimate: Designing the Spaces Between Buildings*; Routledge: Abingdon-on-Thames, UK, 2012.
20. Nouri, A.S.; Costa, J.P. Addressing thermophysiological thresholds and psychological aspects during hot and dry mediterranean summers through public space design: The case of Rossio. *Build. Environ.* **2017**, *118*, 67–90. [[CrossRef](#)]
21. Mandić, L.; Đjukić, A.; Marić, J.; Mitrović, B. A Systematic Review of Outdoor Thermal Comfort Studies for the Urban (Re) Design of City Squares. *Sustainability* **2024**, *16*, 4920. [[CrossRef](#)]
22. Santamouris, M. Using cool pavements as a mitigation strategy to fight urban heat island—A review of the actual developments. *Renew. Sustain. Energy Rev.* **2013**, *26*, 224–240. [[CrossRef](#)]
23. Oke, T.R. *Initial Guidance to Obtain Representative Meteorological Observations at Urban Sites. Instruments and Observing Methods Report n.81*; World Meteorological Organization: Geneva, Switzerland, 2006.
24. *ISO 7726:1998; Ergonomics of the Thermal Environment—Instruments for Measuring Physical Quantities*. International Standardisation Organisation: Geneva, Switzerland, 2006.
25. Pelorosso, R.; Gobattoni, F.; Leone, A. Green Courtyards as Urban Cool Islands: Towards Nature-based climate adaptation plans of compact cities. *CSE-City Saf. Energy* **2017**, *1*, 27–36.
26. McPherson, E.G. *Energy-Conserving Site Design*; American Society of Landscape Architects: New York, NY, USA, 1984.
27. Rahman, M.A.; Stratopoulos, L.M.; Moser-Reischl, A.; Zölch, T.; Häberle, K.-H.; Rötzer, T.; Pretzsch, H.; Pauleit, S. Traits of trees for cooling urban heat islands: A meta-analysis. *Build. Environ.* **2020**, *170*, 106606. [[CrossRef](#)]
28. Alcoforado, M.-J.; Andrade, H. Nocturnal urban heat island in Lisbon (Portugal): Main features and modelling attempts. *Theor. Appl. Climatol.* **2006**, *84*, 151–159. [[CrossRef](#)]
29. Song, W.; Calautit, J.K. Inclusive comfort: A review of techniques for monitoring thermal comfort among individuals with the inability to provide accurate subjective feedback. *Build. Environ.* **2024**, *257*, 111463. [[CrossRef](#)]
30. Wang, Z.; de Dear, R.; Luo, M.; Lin, B.; He, Y.; Ghahramani, A.; Zhu, Y. Individual difference in thermal comfort: A literature review. *Build. Environ.* **2018**, *138*, 181–193. [[CrossRef](#)]

31. Ali, S.B.; Patnaik, S. Thermal comfort in urban open spaces: Objective assessment and subjective perception study in tropical city of Bhopal, India. *Urban Clim.* **2018**, *24*, 954–967. [\[CrossRef\]](#)
32. Lopes, H.S.; Remoaldo, P.C.; Ribeiro, V.; Martín-Vide, J. A comprehensive methodology for assessing outdoor thermal comfort in touristic city of Porto (Portugal). *Urban Clim.* **2022**, *45*, 101264. [\[CrossRef\]](#)
33. Ashrae. *2013 ASHRAE Handbook: Fundamentals*; Ashrae: Peachtree Corners, GA, USA, 2013.
34. Andrade, H.; Alcoforado, M.-J.; Oliveira, S. Perception of temperature and wind by users of public outdoor spaces: Relationships with weather parameters and personal characteristics. *Int. J. Biometeorol.* **2011**, *55*, 665–680. [\[CrossRef\]](#)
35. Martín-Vide, J.; Artola, V.; Cordobilla, M.; Moreno, M.d.C. *METROBS-La Isla de Calor en el Área Metropolitana de Barcelona y la Adaptación al Cambio Climático*; Área Metropolitana de Barcelona: Barcelona, Spain, 2015.
36. Alcoforado, M.-J.; Andrade, H.; Lopes, A.; Vasconcelos, J. Application of climatic guidelines to urban planning: The example of Lisbon (Portugal). *Landsc. Urban Plan.* **2009**, *90*, 56–65. [\[CrossRef\]](#)
37. Oliveira, A.V.M.; Gaspar, A.R.; Quintela, D.A. Dynamic clothing insulation. Measurements with a thermal manikin operating under the thermal comfort regulation mode. *Appl. Ergon.* **2011**, *42*, 890–899. [\[CrossRef\]](#)
38. Algeciras, J.A.R.; Consuegra, L.G.; Matzarakis, A. Spatial-temporal study on the effects of urban street configurations on human thermal comfort in the world heritage city of Camagüey-Cuba. *Build. Environ.* **2016**, *101*, 85–101. [\[CrossRef\]](#)
39. Shashua-Bar, L.; Hoffman, M.E. Vegetation as a climatic component in the design of an urban street: An empirical model for predicting the cooling effect of urban green areas with trees. *Energy Build.* **2000**, *31*, 221–235. [\[CrossRef\]](#)
40. Souch, C.; Souch, C. The effect of trees on summertime below canopy urban climates: A case study Bloomington, Indiana. *J. Arboric* **1993**, *19*, 303–312. [\[CrossRef\]](#)
41. Perini, K.; Magliocco, A. Effects of vegetation, urban density, building height, and atmospheric conditions on local temperatures and thermal comfort. *Urban For. Urban Green.* **2014**, *13*, 495–506. [\[CrossRef\]](#)
42. Stathopoulou, M.; Synnefa, A.; Cartalis, C.; Santamouris, M.; Karlessi, T.; Akbari, H. A surface heat island study of Athens using high-resolution satellite imagery and measurements of the optical and thermal properties of commonly used building and paving materials. *Int. J. Sustain. Energy* **2009**, *28*, 59–76. [\[CrossRef\]](#)
43. Pushkarev, B.; Zupan, J.; Pushkarev, B.; Zupan, J.M. Capacity of walkways. *Transp. Res. Rec.* **1975**, *538*, 1–15.
44. Nikolopoulou, M.; Steemers, K. Thermal comfort and psychological adaptation as a guide for designing urban spaces. *Energy Build.* **2003**, *35*, 95–101. [\[CrossRef\]](#)
45. Vidal, D.G.; Teixeira, C.P.; Fernandes, C.O.; Olszewska-Guizzo, A.; Dias, R.C.; Vilaça, H.; Barros, N.; Maia, R.L. Patterns of human behaviour in public urban green spaces: On the influence of users' profiles, surrounding environment, and space design. *Urban For. Urban Green.* **2022**, *74*, 127668. [\[CrossRef\]](#)
46. Berger, P.; Luckmann, T. The social construction of reality. In *Social Theory Re-Wired*; Routledge: Abingdon-on-Thames, UK, 2016; pp. 110–122.
47. Lefebvre, H. La production de l'espace. *L'Homme Société* **1974**, *31*, 15–32. [\[CrossRef\]](#)
48. Bordin, G.; Toso, E.; Carvalho, A. Creative Activism and Tactical Urbanism: Social Change in Milan through Colourful Squares. *Art Urban Commons Soc. Change* **2023**, *4*, 53–71.
49. Suwanmanee, N.; Kronprasert, N.; Sutheerakul, C.; Arunotayanun, K.; Rinchumphu, D. Investigation of Outdoor Thermal Comfort for Campus Pedestrian Walkways in Thailand. *Sustainability* **2024**, *16*, 657. [\[CrossRef\]](#)
50. PPS. *How to Turn a Place Around: A Handbook for Creating Successful Public Spaces*; Project for Public Spaces (PPS): New York, NY, USA, 2000.
51. Foucault, M.; Miskowiec, J. Of other spaces. *Diacritics* **1986**, *16*, 22–27. [\[CrossRef\]](#)

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.