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# Climate-Responsive Strategies for Enhancing Outdoor Thermal Comfort and Pedestrian Walkability in Climatic zones: A Systematic Review

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## Abstract

Outdoor thermal comfort (OTC) plays a central role in shaping how people walk, move, and interact in cities. With rising temperatures driven by urbanization and climate change, creating comfortable outdoor spaces has become increasingly important for liveability and health. This review explores how microclimatic factors—such as temperature, humidity, solar radiation, wind, and shading—affect pedestrian comfort across different climatic zones. Using the PRISMA framework, peer-reviewed studies were systematically reviewed to identify climate-responsive design strategies. The evidence shows that interventions like tree canopies, shaded walkways, reflective surfaces, and well-ventilated corridors can significantly improve outdoor comfort and support sustainable mobility. A key finding is the contrast between developed and developing cities: while developed regions often employ advanced technologies and green infrastructure, developing cities face challenges of rapid growth, limited resources, and inadequate shading, making low-cost, context-specific solutions essential. Overall, the review highlights that combining vegetation, reflective materials, and airflow-sensitive urban design can reduce heat stress, promote walkability, and build resilience, ultimately creating healthier and more inclusive urban environments.

## Keywords

Climate-Responsive Urban Design, Microclimatic Factors, Outdoor Thermal Comfort (OTC), Pedestrian Behaviour, Sustainable Walkability, Urban Heat Mitigation

## 1. Introduction

Outdoor thermal comfort (OTC) plays a vital role in shaping pedestrian behaviour and movement within urban streets, influencing walkability, social interaction, and the overall quality of urban life [1]. With cities facing rising temperatures driven by rapid urbanization and climate change, the creation of thermally comfortable outdoor spaces has become a priority in both urban planning and architectural practice [2]. Although substantial evidence highlights the influence of OTC, comprehensive studies that integrate meteorological parameters with pedestrian behaviour across varied urban contexts remain limited [2].

This review systematically examines the impact of OTC on pedestrian behaviour, focusing on how material properties, microclimatic variations, and urban structural design affect comfort and heat perception [3]. Key climatic elements such as temperature, humidity, solar radiation, and wind patterns not only shape physical comfort but also determine mobility patterns in both the short and long term. Evidence shows that sustainable urban planning, through shading, ventilation, and temperature regulation, can significantly enhance walkability, with shaded and well-ventilated streets increasing pedestrian activity by 20–30% compared to unshaded areas [4].

In addition to immediate thermal comfort, climate-sensitive design supports long-term resilience by reducing heat stress, lowering energy consumption, and improving public health, thereby strengthening cities' adaptability to climate change [1]. Interventions such as green corridors, reflective materials, and blue infrastructure not only foster pedestrian comfort but also contribute to improved air quality and biodiversity. Acknowledging the contrasting capacities of developed and developing cities, this study draws comparative insights, emphasizing strategies such as optimizing vegetation cover, enhancing surface reflectivity, and improving airflow to foster pedestrian-friendly and climate-responsive urban environments [5].

To address these gaps, the review is guided by the following key questions:

1. How do microclimatic parameters—air temperature, humidity, solar radiation, and wind patterns—interact with urban form and material characteristics to influence outdoor thermal comfort and pedestrian behaviour?
2. What climate-responsive design strategies most effectively enhance OTC and encourage walkability across different climatic zones and levels of urban development?
3. How do the adaptive approaches of developed and developing cities differ, and what transferable lessons can inform context-specific planning for resilient, pedestrian-friendly environments?

## 2. Methodology

This study adopts a qualitative systematic literature review to investigate the influence of outdoor thermal comfort (OTC) on pedestrian behaviour in urban street environments, with emphasis on different climatic zones [4]. The review process follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, ensuring that the identification, screening, and evaluation of studies are conducted in a structured, transparent, and replicable manner. Relevant literature was sourced from multiple academic databases, including Scopus, Web of Science, Google Scholar, and ScienceDirect [6].

**2.1 Search Strategy:** A focused literature search was conducted using a defined set of keywords, including "Outdoor Thermal Comfort," "Pedestrian Behaviour," "Urban Microclimate," "Thermal Adaptation," "Urban Heat Mitigation," "Shading," "Green Infrastructure," "Sky View Factor," "Walkability," and "Thermal Sensation Votes" [7]. To refine the results and eliminate irrelevant studies, Boolean operators (AND, OR, NOT, NEAR, WITH) were systematically applied. Examples of such search strings include "Outdoor Thermal Comfort AND Pedestrian Behaviour" and "Urban Microclimate OR Thermal Adaptation." Only studies published in the previous decade were included to maintain contemporary relevance[8].

**2.2 Data Collection and Selection Process:** The initial database search yielded **150 studies,** with an additional **50 from other sources.** After duplicate removal, **100 unique records** entered the screening phase, focusing on urban environments with hot and dry climatic conditions. Titles and abstracts were reviewed for relevance, and **75 full-text articles** were critically assessed using pre-established inclusion and exclusion criteria. Of these, **55 articles were excluded**, resulting in **20 studies** being included in the final qualitative synthesis.

### 2.3 Inclusion and Exclusion Criteria

- **Inclusion Criteria:** Peer-reviewed articles conducted in urban environments, providing **measurable data on temperature variations, thermal sensation votes (TSVs), or established thermal comfort indices** such as PET (Physiological Equivalent Temperature), UTCI (Universal Thermal Climate Index), or mPET[9].
- These criteria were chosen because urban areas face distinct microclimatic challenges, including urban heat island effects, localized shading, and altered wind patterns, all of which directly impact pedestrian comfort[10].
- **Exclusion Criteria:** Studies lacking quantitative or qualitative assessment of temperature variations or pedestrian responses in hot/dry urban climates, as well as grey literature, conference proceedings, opinion pieces, or non-peer-reviewed articles relevant to these contexts[11].

**2.4 Synthesis and Analysis:** From the eligibility phase, 20 key articles were selected for qualitative synthesis. Recurring variables (temperature, shading, wind) were observed and studies were categorized by climatic factors and the type of design interventions applied. Cross-comparisons were also made between developed and developing cities to expand the analysis and ensure robust, context-specific insights[12].

This **systematic approach using the PRISMA workflow** underpins the reliability of the review, allowing for a comprehensive assessment of current knowledge on OTC and its implications for pedestrian comfort, safety, and urban mobility across different climatic and urban settings[13].

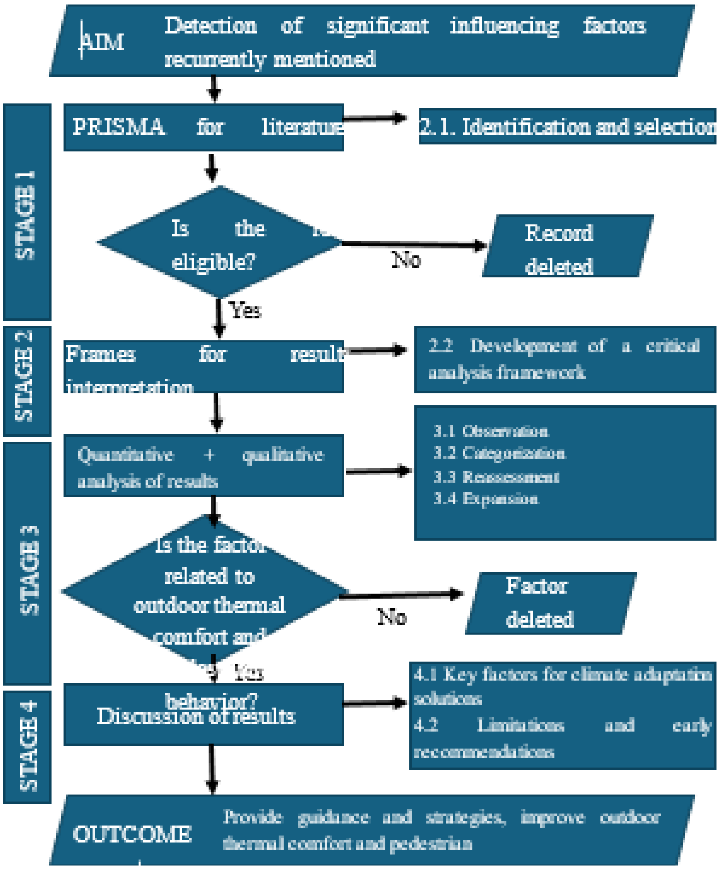


**Figure 1.** Systematic workflow of the study following the PRISMA framework

Figure 1 illustrates the systematic workflow adopted in this study, structured across four main stages. In **Stage 1 (Identification and Selection)**, records were retrieved through the PRISMA protocol and assessed for eligibility; non-relevant records were excluded at this stage[14]. **Stage 2 (Framework Development)** involved creating a critical analysis framework to interpret the results through observation, categorization, reassessment, and expansion. In **Stage 3 (Analysis of Results),** both quantitative and qualitative assessments were carried out to identify recurring microclimatic variables and their influence on outdoor thermal comfort and pedestrian behaviour. Records or factors that did not meet the criteria were excluded. **Stage 4 (Discussion and Synthesis)** integrated the validated results into key themes, including climate adaptation strategies, limitations, and early recommendations. The overall outcome of this process was the development of a set of context-specific strategies aimed at enhancing outdoor thermal comfort and promoting pedestrian-friendly urban environments[11].

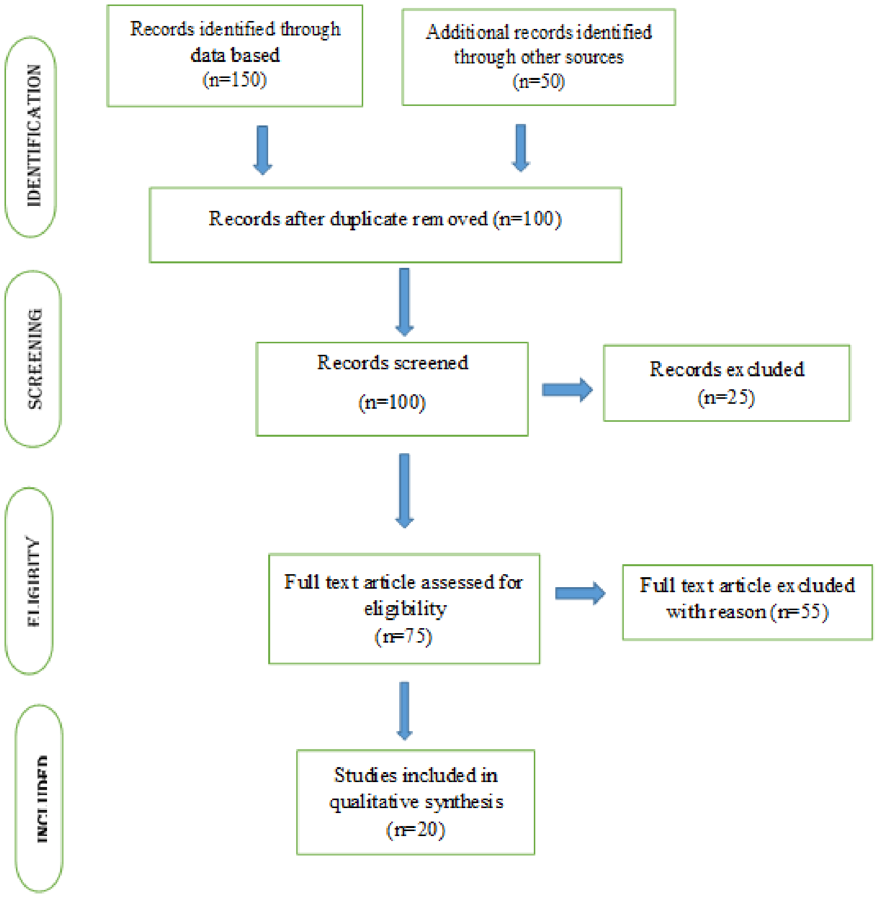


**Figure 2.** PRISMA flow diagram of study selection process.

**Figure 2** presents the PRISMA-based selection process used in this review. A total of **150 records** were identified through database searches, with an additional **50 records** retrieved from other sources[8]. After removing duplicates, **100 records** remained for screening. Following title and abstract review, **25 records** were excluded, leaving **75 full-text articles** assessed for eligibility[15]. Of these, **55 articles** were excluded as they did not meet the predefined criteria, resulting in **20 studies** being included in the final qualitative synthesis. This stepwise process ensured that only the most relevant and reliable studies were considered for analysis[16].

## 3. Results

**3.1 Impact of Outdoor Thermal Comfort on Pedestrian Behaviour:** The findings of this systematic review highlight the complex interaction between outdoor thermal comfort (OTC), microclimatic conditions, and pedestrian behaviour in urban environments[17]. OTC is strongly shaped by a set of interrelated climatic variables, including **solar radiation, air temperature, wind flow, and relative humidity**, all of which affect pedestrians' thermal sensation and willingness to use outdoor spaces[18]. The **urban heat island (UHI) effect,** intensified by dense built-up surfaces, vehicular emissions, and low vegetation cover, was found to significantly exacerbate discomfort, especially during peak daytime hours in hot and dry climatic zones[19]. In addition to environmental influences, **individual and psychological factors** emerged as critical modifiers of pedestrian responses[20]. Studies consistently noted that thermal perception varies with **age, gender, acclimatization, and personal expectations,** suggesting that comfort thresholds cannot be generalized across all population groups[9]. For instance, elderly pedestrians demonstrated lower tolerance to heat stress, whereas younger groups showed higher adaptability, albeit still seeking relief in shaded environments when exposure exceeded certain thresholds[21].

**Field studies and observational evidence** provided quantitative thresholds for pedestrian behaviour[22]. A consistent pattern was observed in hot and dry climates, where pedestrians actively sought **shaded zones** when temperatures rose to **31–33 °C in the morning** and **36–37 °C at midday[19].** Beyond these thresholds, pedestrian activity significantly declined, confirming the role of shading as a decisive factor in sustaining walkability.

The review also emphasizes the importance of **surface materials and urban greenery** in modulating thermal comfort[18]. Hard surfaces such as **asphalt and concrete** were found to retain and re-radiate heat, contributing to elevated surface and air temperatures. In contrast, **vegetation, tree canopies, and grass-covered areas** acted as natural cooling systems, reducing mean radiant temperature (MRT) and improving thermal sensation votes (TSVs)[23]. **Reflective pavements and light-coloured surfaces** offered intermediate benefits by lowering heat storage, though their performance varied depending on solar exposure and maintenance[24].

Spatial and seasonal variations further underline the importance of **urban morphology** in shaping thermal conditions. The **sky view factor (SVF)** and **building orientation** were frequently cited as determinants of microclimatic quality[12]. Narrow streets with reduced SVF offered greater shading but limited ventilation, while open spaces promoted airflow but increased solar exposure[10]. Seasonal analyses revealed that these trade-offs vary across summer and winter, requiring context-specific design strategies.

Taken together, these results demonstrate that pedestrian comfort is the outcome of **both physical microclimate conditions and human adaptability[25].** The synthesis of evidence from the 20 included studies confirms that interventions such as **tree canopies, shaded walkways, reflective pavements, ventilation corridors, and green–blue infrastructure** are effective in mitigating thermal stress and encouraging pedestrian movement. These findings provide the empirical foundation for the subsequent discussion on climate-responsive urban design strategies, resilience planning, and sustainable walkability[7].

| Factor | Observed Behavioural Response | Design Implication | Reference |
|---|---|---|---|
| High solar radiation | Preference for shaded sidewalks and covered walkways | Increased tree canopy, shade structures | [24][25] |
| High air temperature | Reduced outdoor activity during peak heat | Cool pavements, reflective materials | [8] |
| Wind exposure (summer) | Pedestrians seek breezy corridors for ventilation | Street canyon design to improve airflow | [10][11] |
| Wind exposure (winter) | Pedestrians avoid wind-exposed areas | Protective walkways, partial enclosures | [12][25] |
| Humidity levels | Higher discomfort under high radiant temperatures | Vegetation and evaporative cooling | [9] |

**Table 1**. Microclimatic factors, pedestrian responses, and design implications.

**Table 1** summarizes the relationship between key microclimatic factors, pedestrian behavioural responses, and their design implications in urban environments. The findings show that **high solar radiation** drives a strong preference for shaded sidewalks and covered walkways, emphasizing the importance of increasing tree canopy and shade structures[4]. High air temperatures significantly reduce outdoor activity during peak hours, emphasizing the importance of cool pavements and reflective materials in lowering surface heat. Seasonal wind conditions also shape pedestrian preferences: in summer, well-ventilated corridors created by street canyon design are preferred for cooling, while in winter, wind-exposed areas are avoided, making protective walkways and partial enclosures essential [26]. Humidity further intensifies discomfort when combined with high radiant temperatures, indicating the value of vegetation and evaporative cooling in enhancing outdoor thermal comfort. Collectively, these findings highlight the importance of climate-responsive urban design that combines shading, appropriate material use, airflow optimization, and greenery to improve pedestrian comfort and walkability [27]. 3.2 Pedestrian Behaviour Toward Climatic Determinants: Climatic factors including air temperature, humidity, solar radiation, and wind flow directly affect pedestrian thermal comfort. When air temperatures exceed 40 °C and mean radiant temperatures rise to nearly 50 °C, walking activity declines sharply, especially in zones dominated by impervious concrete surfaces [21]. In contrast, vegetated streetscapes help maintain lower surface temperatures and are consistently preferred as pedestrian routes[18]. Humidity levels of 20–30% during peak summer months alter sweat evaporation and intensify thermal discomfort, while restricted airflow in narrow street canyons lowers wind speeds below 1.5 m/s, trapping heat and reducing comfort[19]. Conversely, open urban spaces with wind speeds around 3.0 m/s promote convective heat dissipation, thereby improving outdoor comfort. Beyond environmental conditions, clothing insulation and metabolic activity further contribute to thermal burden, with a walking pace of 4 km/h generating an additional ~100 W/m$^2$ of metabolic heat[24].

| Climatic Factor | Condition | Impact on Comfort | Observed Behaviour | Reference |
|---|---|---|---|---|
| Temperature | >40 °C, radiant ~50 °C | Extreme heat stress | Reduced walking; preference for shaded paths | [25] |
| Humidity | 20–30% (low humidity) | Supports evaporation and cooling | Tolerable, but discomfort at high radiation | [28] |
| Wind speed | <1.5 m/s in narrow streets | Heat trapped, poor ventilation | Avoidance of narrow/high-density areas | [29] |
| Wind speed | ~3.0 m/s in open corridors | Effective cooling | Preference for open/breezy streets | [21] |
| Clothing/metabolic | Traditional attire + walking at 4 km/h | Adds ~100 W/m$^2$ thermal load | Increased discomfort during heat periods | [11] |

Table 2 shows how weather and metabolism affect pedestrian comfort and behavior.

**Table 2** outlines the influence of key climatic and physiological factors on pedestrian comfort and behaviour in urban environments. At air temperatures exceeding 40 °C with radiant values around 50 °C, pedestrians experience extreme heat stress, leading to reduced walking activity and a preference for shaded pathways[22]. Humidity levels between 20–30% can support cooling through sweat evaporation; however, discomfort remains considerable under intense solar radiation [23]. Wind speed is another critical factor: in narrow streets where airflow falls below 1.5 m/s, heat accumulates and ventilation decreases, leading pedestrians to avoid dense urban corridors. Conversely, open spaces with wind speeds around 3.0 m/s provide effective cooling and are more attractive for pedestrian movement [17]. Beyond these environmental influences, clothing and metabolic activity also add to thermal stress, as traditional attire combined with walking at 4 km/h generates approximately 100 W/m$^2$ of additional heat, intensifying discomfort during hot periods [18]. These findings highlight the intricate relationship between climatic conditions, human physiology, and adaptive behaviour in shaping outdoor thermal comfort.

**3.3 Comparative Analysis: Developed vs. Developing Cities:**A comparative analysis of outdoor thermal comfort (OTC) strategies reveals a distinct divergence in approach between developed and developing urban contexts, primarily driven by disparities in infrastructural capacity and resource availability[20]. In developed cities, mitigation efforts frequently leverage advanced technological interventions, including smart cooling systems, high-albedo pavements, and integrated green-blue infrastructure[27]. Conversely, developing cities predominantly employ nature-based solutions—such as augmenting vegetation cover, expanding shaded corridors, and optimizing airflow through street canyon morphology—to ameliorate microclimatic conditions[12]. This dichotomy underscores the critical importance of context-specific urban design that strategically balances technological investment with sustainable, locally viable practices to enhance pedestrian thermal sensation, walking frequency, and overall urban liveability across diverse climatic and economic settings[30].

**3.3.1 Outdoor Thermal Comfort in Developed Urban Areas:** Empirical evidence illustrates a clear contrast in the application of urban heat mitigation strategies between developed and developing cities[31]. Developed urban areas typically implement engineered solutions; for example, reflective pavements in Australia reduce perceived temperatures by 5–7 °C, and ventilation corridors in Tokyo diminish pedestrian heat stress by 15–20%[6]. Singapore further demonstrates the efficacy of combined evaporative cooling and vegetation, achieving a 2–3 °C reduction in ambient heat. In contrast, developing cities predominantly utilize nature-based interventions. Case studies show green corridors can lower surface temperatures by 7–9 °C, and shaded streets in Cairo improve Physiological Equivalent Temperature based comfort by 30–35%. Despite their effectiveness, the implementation of these strategies in developing contexts is frequently hampered by challenges such as insufficient vegetation cover, rapid urbanization, and inadequate planning[32]. This is evidenced in cities with vegetation cover below 20%, which correlate with 35–40% higher pedestrian heat stress compared to areas exceeding 30% cover[33]. Consequently, these findings advocate for a hybrid mitigation framework that integrates technologically advanced solutions with robust nature-based strategies to effectively enhance outdoor thermal comfort in rapidly urbanizing regions globally.

**3.3.2 Outdoor Thermal Comfort in Developing Urban Areas:** Developing cities encounter amplified challenges in mitigating urban heat, primarily driven by rapid urbanization, extensive use of asphalt-dominated surfaces, and insufficient implementation of cooling measures[2]. In Indian cities, unshaded asphalt streets often record extreme surface temperatures of up to 50 °C, while shaded green corridors provide a notable cooling effect, lowering temperatures by 7–9 °C [13]. Likewise, studies in Cairo show that shaded areas enhanced pedestrian comfort by 30–35% based on the Physiological Equivalent Temperature (PET) index, although the city continues to struggle with critically low levels of green coverage [34].These cases underscore that although natural shading and vegetation offer considerable cooling potential, their benefits are often curtailed by the absence of systematically integrated, climate-responsive urban design[1]. The persistent use of heat-retaining materials like asphalt and concrete in expanding urban areas further intensifies the urban heat island effect and diminishes walkability[5]. Compounding these issues are socio-economic constraints, weak policy enforcement, and competing land-use priorities, which collectively obstruct the large-scale adoption of green infrastructure[3]. To overcome these barriers, developing cities should pursue a hybrid planning approach that synergistically combines affordable nature-based strategies—such as expanded tree planting and shaded corridors—with targeted engineered solutions like reflective pavements and optimized street geometry. This integrated framework is essential for advancing toward resilient, pedestrian-friendly urban environments, particularly in hot and dry climatic regions[8].

Table 3: Urban Heat Mitigation Strategies and Impacts

| Context | Intervention | Observed Impact | Reference |
|---|---|---|---|
| Australia | Reflective pavements, shaded walkways | 5–7 °C reduction in surface temperatures | [23] [25] |
| Singapore | Water features + shade structures | 2–3 °C reduction, enhanced cooling | [23] [15] |
| Tokyo | Ventilation corridors | 15–20% reduction in heat stress | [23] [15] |
| Indian cities | Green corridors | 7–9 °C reduction in surface temperatures | [12] [25] |
| Cairo | Shaded streets | 30–35% higher comfort (PET-based) | [28] [15] |
| Jakarta / São Paulo | <20% vegetation cover | 35–40% higher pedestrian heat stress than ≥30% vegetation | [28] [25] |

**Table 3 compares urban heat mitigation strategies adopted across different cities and highlights their observed impacts** [30]**.** In Australia, the use of reflective pavements and shaded walkways has reduced surface temperatures by 5–7 °C, showing the effectiveness of material choice and shading in moderating heat[14]. Singapore combines water features with shade structures, achieving a 2–3 °C temperature reduction while also enhancing evaporative cooling and comfort. Tokyo's approach of creating ventilation corridors has successfully reduced pedestrian heat stress by 15–20%, demonstrating the importance of airflow management in dense urban settings[11] . Indian cities, where asphalt-dominated surfaces cause severe heat accumulation, have observed a 7–9 °C reduction in surface temperatures through the introduction of green corridors, proving vegetation to be one of the most effective strategies[15]. Similarly, shaded streets in Cairo improved outdoor comfort by 30–35% based on PET (Physiological Equivalent Temperature) indices. In contrast, cities like Jakarta and São Paulo with less than 20% vegetation cover experienced 35–40% higher pedestrian heat stress compared to areas with more than 30% vegetation, further underlining the critical role of green infrastructure[28]. Collectively, these cases reveal that while developed cities rely more on engineered solutions such as reflective materials, ventilation corridors, and water features, developing cities depend heavily on natural shading and vegetation—yet both approaches converge in demonstrating the significant role of greenery and shading in reducing urban heat stress and improving pedestrian comfort [10].

**3.4.1 Green and Blue Infrastructure:** The strategic integration of greenery and water bodies into the urban fabric, known as Green-Blue Infrastructure (GBI), presents a highly effective strategy for microclimatic regulation and the enhancement of outdoor thermal comfort[12]. Empirical evidence indicates that a substantial increase in tree canopy cover—approximately 40%—can reduce the Universal Thermal Climate Index (UTCI) by 1.5 to 2.0 Kelvin[35]. This reduction signifies a perceptible shift in human thermal sensation, often moving from conditions of 'strong heat stress' to 'moderate heat stress,' thereby making outdoor environments more conducive to pedestrian activity and longer dwell times[22].The synergistic effect of combining green (parks, trees, green roofs) and blue (ponds, streams, fountains) elements further amplifies these benefits. As demonstrated in the cases of Brisbane, Australia, and Guangzhou, China, such integrated GBI systems function through two primary mechanisms:

- Evapotranspiration: Plants release moisture into the air, a process that consumes ambient heat energy and provides natural evaporative cooling[21].
- Shading and Albedo: Tree canopies intercept solar radiation before it heats up ground-level surfaces and the air, while water bodies typically have a higher albedo than asphalt or concrete, reflecting more sunlight[16].

The considerable reduction in ambient temperatures achieved through such interventions directly mitigates the urban heat island effect. Beyond thermal comfort, these measures provide multiple co-benefits [27]. Vegetation functions as a natural air filter, removing pollutants and particulate matter [18], while also offering psychological and restorative advantages through access to green spaces. Together, these effects contribute to better public health outcomes, including lower rates of heat-related illnesses and reduced stress. Thus, investment in green and blue infrastructure (GBI) should be viewed not only as a climate adaptation measure but also as an integrated strategy to promote sustainable, resilient, and livable urban environments [20].

**3.4.2 Microclimate Management:** High-albedo, or reflective, pavements represent an important engineered approach for reducing heat accumulation on urban surfaces [26]. Evidence from Los Angeles indicates that these materials can lower ground temperatures by nearly 5 °C, as they reflect a higher fraction of solar radiation than conventional asphalt. By decreasing surface heating, this intervention also reduces mean radiant temperature (MRT), a critical determinant of human thermal comfort and perception [19]. Complementing material strategies, the optimization of street canyon geometry—such as adjusting building height-to-width ratios—is a fundamental design approach for enhancing urban airflow[20]. By strategically channeling wind through urban corridors, this method improves convective heat loss and dissipates trapped heat, thereby reducing the overall thermal load on pedestrians. However, the efficacy of these interventions is not universal and is often constrained by local context[17]. In many developing cities, such as Cairo, the potential benefits of isolated improvements, like those measured by the Physiological Equivalent Temperature (PET) index, are frequently undermined by a persistent and overarching lack of shading. Without adequate tree canopies or shade structures, pedestrians remain directly exposed to solar radiation, severely limiting gains in comfort from other measures[27]. The significant impact of comprehensive climate-responsive design is unequivocally demonstrated by the behavioral data of pedestrians[28]. Urban areas that successfully integrate shading with other thermally conscious infrastructure report a 20–30% increase in pedestrian activity on treated routes compared to exposed, unshaded alternatives. This stark contrast underscores that thermal comfort is a primary determinant of urban walkability[2]. It confirms that investments in a multi-faceted strategy—encompassing reflective materials, aerodynamic urban morphology, and, most crucially, pervasive shading—are essential for revitalizing pedestrian life and encouraging sustainable mobility, particularly in heat-prone regions[17].

Table 4: Microclimate Strategies and Pedestrian Impact

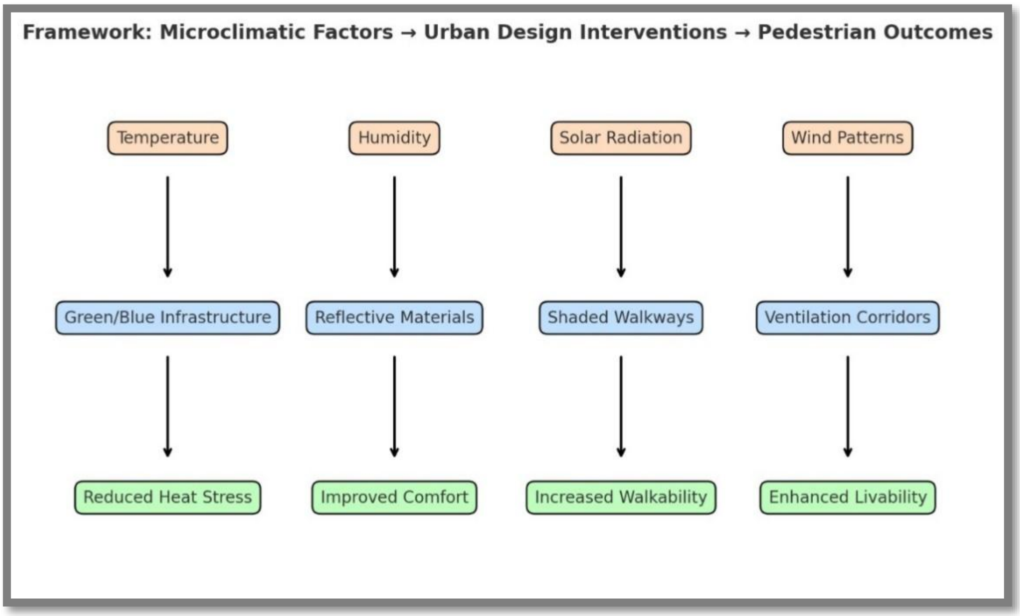
| Strategy | Effect on Microclimate | Impact on Pedestrian Behaviour | reference |
|---|---|---|---|
| Tree canopies & green roofs | Reduce UTCI by 1.5–2.0 K | Encourage shaded route selection | [23] |
| Blue infrastructure (fountains, ponds) | Evaporative cooling; lower ambient temp by 2–3 °C | Increase stay duration in outdoor spaces | [29] |
| Reflective pavements | Reduce ground temp by ~5 °C | Promote walking during daytime | [35] |
| Ventilation corridors | Reduce heat stress by 15–20% | Improve comfort in high-density areas | [17] |
| Shaded seating + walkways | Reduce perceived temp by 5–7 °C | Increase walkability and social activity | [7] |

Table 4 presents a range of strategies for improving microclimatic conditions and their corresponding impacts on pedestrian behaviour[23]. Tree canopies and green roofs help reduce the Universal Thermal Climate Index (UTCI) by 1.5–2.0 K, encouraging people to select shaded routes and reducing direct heat exposure[29]. Blue infrastructure such as fountains and ponds enhances evaporative cooling and lowers ambient temperatures by 2–3 °C, which increases the duration of outdoor stays and promotes social interaction in public spaces[35]. Reflective pavements reduce ground temperatures by approximately 5 °C, making walking during the daytime more comfortable and viable[17]. Ventilation corridors, designed to channel airflow through dense urban areas, can reduce heat stress by 15–20%, thereby improving comfort in high-density neighbourhoods. Finally, shaded seating areas and covered walkways can lower perceived temperatures by 5–7 °C, significantly boosting walkability and encouraging greater social activity in outdoor environments [30]. Collectively, these strategies demonstrate how integrated microclimate-sensitive planning can transform urban spaces into more thermally comfortable, walkable, and socially vibrant environments[7].

Figure 2: Framework linking climate factors, design strategies, and pedestrian outcomes

The relationship between microclimatic factors, urban design strategies, and their impact on pedestrian outcomes is illustrated in Figure 2. Temperature regulation through green and blue infrastructure helps reduce heat stress, while the use of reflective materials under humid conditions improves comfort[29]. Solar radiation can be mitigated with shaded walkways, which directly enhance walkability by providing cooler and safer pedestrian routes. Wind patterns, when managed through ventilation corridors, improve airflow in dense urban settings and contribute to enhanced liveability[17]. Together, these interventions highlight the importance of integrating climate-responsive design into urban planning to create more comfortable, walkable, and resilient environments[35].

Here's a conceptual framework figure showing how *microclimatic factors* influence *urban design interventions*, which then lead to *pedestrian outcomes*.



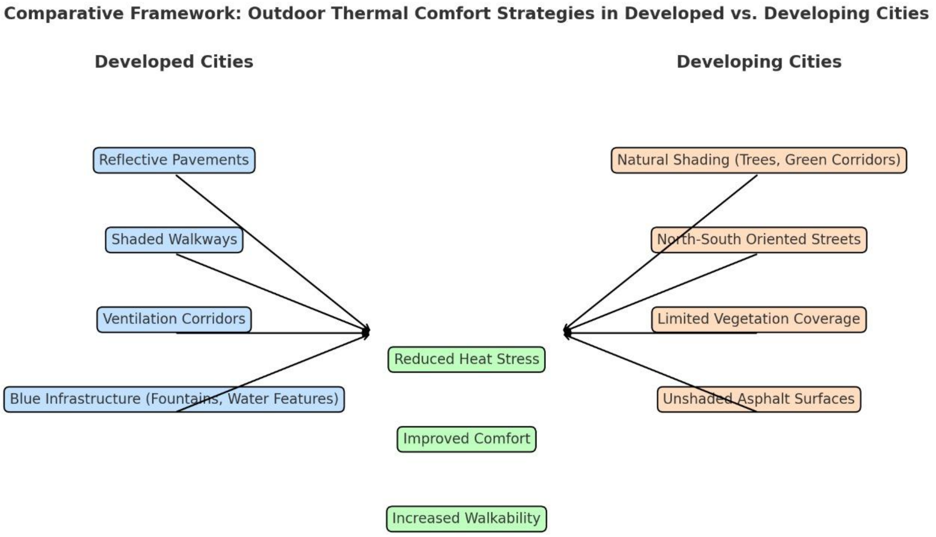


Figure 3: Comparative framework of OTC strategies in developed and developing cities

A comparative framework of outdoor thermal comfort strategies in developed versus developing cities is illustrated in Figure 3. In developed cities, the strategies shown—reflective pavements, shaded walkways, ventilation corridors, and blue infrastructure like fountains and water features—are often technology-driven and require significant financial investment[25]. In contrast, developing cities tend to depend on natural and cost-effective solutions, such as tree shading, green corridors, and the orientation of streets along a north-south axis to limit solar exposure [14]. The diagram illustrates that despite differences in approach, both developed and developing cities ultimately pursue similar goals: lowering heat stress, enhancing thermal comfort, and encouraging walkability [30]. Overall, the figure captures how cities, depending on their economic and developmental capacity, follow different yet parallel strategies to mitigate the urban heat island effect [3].

## 4. Discussion

This review shows that microclimatic conditions have a strong impact on outdoor thermal comfort (OTC) and influence how people move around cities. Factors like street design, shading, and airflow play an important role in how pedestrians experience heat, which makes climate-sensitive urban design essential. People's preference for shaded and breezy routes makes it clear that heat not only affects comfort but also shapes how long and how far they are willing to walk.Across different climates, the same ideas of adapting to heat appear, but they are used in different ways. In Mediterranean cities, narrow and compact streets give useful shade but often trap heat because of poor airflow. In hot and humid regions, adding greenery and water features helps lower temperatures and makes outdoor spaces more comfortable. European cities highlight another benefit—tree-lined avenues and shaded public spaces not only keep areas cooler but also encourage walking, social interaction, and a stronger sense of community.The synthesis of global evidence confirms that sustainable design for OTC is indispensable for creating pedestrian-friendly cities. The incorporation of green-blue infrastructure, the strategic optimization of urban morphology, and the application of climate-responsive materials collectively enhance comfort, support active mobility, and foster healthier urban environments. This urgency is amplified by climate change, necessitating the prioritization of these measures in cities worldwide.This consensus is further supported by evidence from rapidly growing Asian metropolises, where the urban heat island effect intensifies pedestrian discomfort, especially in areas devoid of vegetation. Effective countermeasures include reflective pavements, vertical greening, and deliberate building orientation to minimize solar gain. Parallel findings from hot-arid cities like Tehran and Riyadh show how urban heat islands exacerbate thermal stress and diminish walkability. Research from China illustrates that dense vegetation can lower air temperatures by 4–6 °C, while studies in Melbourne confirm that well-ventilated urban designs significantly improve pedestrian cooling and comfort. An additional physiological factor is the metabolic heat generated from walking, which at a pace of 4 km/h adds a substantial thermal burden of over 100 W/m², intensifying the sensation of discomfort. In conclusion, this review shows that building walkable and heat-resilient cities requires a combined design approach that brings together shading, ventilation, and greenery. By drawing lessons from different climate zones, the study emphasizes the urgent need for urban planning to adopt climate-responsive strategies that can ensure healthier, more sustainable cities for the future.

## 5. Conclusion

This review shows that outdoor thermal comfort (OTC) has a major influence on how people walk and use city spaces. Factors like sunlight, temperature, wind, humidity, and the way streets are designed all play a big role in shaping comfort. Solutions such as planting more trees, creating shaded walkways, using reflective materials, and improving ventilation have been shown to lower heat stress and encourage more walking. In developed cities, advanced options like reflective pavements, cooling technologies, and green-blue infrastructure are often used, while developing cities depend more on natural methods such as tree canopies and shaded streets. However, rapid urban growth and limited resources often make these measures harder to apply, leaving many areas exposed to greater heat stress. This contrast shows the importance of context-specific planning. By combining affordable natural solutions with selective technologies, cities can achieve real improvements, as seen in places where climate-responsive design has led to more pedestrian activity. A balanced approach that blends shading, greenery, ventilation, and reflective surfaces offers a practical path for creating cooler, healthier, and more walkable cities in a warming world.

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