http://www.press.ierek.com

ISSN (Print: 2357-0849, online: 2357-0857)

Environmental Science and Sustainable Development

Received: 14 October 2023, Accepted: 21 November 2023, Published online: 31 December 2023
DOI: 10.21625/essd.v8i2.1037

Investigating The Transient Thermal Aeraulic Conditions of The 'Sabat' Space in Traditional Mediterranean Cities: The Case of Algiers' Casbah

Sabah Ali-Smail[1], Moussadek Djenane[2], Noureddine Zemmouri[3]

[1]*Ph.D. student, LACOMOFA laboratory, Architecture Department, Mohamed Khider University of Biskra, Algeria*

[2]*Research and Teaching Associate, LACOMOFA laboratory, Architecture Department. Mohamed Khider University of Biskra, Algeria*

[3]*Assistant Professor, LACOMOFA Laboratory, Architecture Department, Mohamed Khider University of Biskra, Algeria*

Abstract

Cities are already experiencing the effect of climate change on their seasonal conditions, especially in the Mediterranean region where significant temperature increases are being observed. Walkability is an essential factor influenced by the global warming impacts and could significantly reshape the course of its magnitude. The current study is a part of a large research investigating the influence of transient thermal aeraulic conditions of 'Sabat' space, a traditional urban in-between space, on pedestrians' walking experience in Mediterranean cities. The aim is to investigate the potential of Sabat in supporting a positive walking experience. The novel 'thermal walk' method was carried out to capture the dynamic pedestrian sensations, simultaneously, with mobile micrometeorological within two preselected walking routes in Algiers' Casbah. This paper reports the mobile meteorological measurement of the 'Casbah walk' with the aim of exploring the potential of Sabat in generating transient thermal aeraulic conditions. The measurement campaigns were carried out for five days in late December (2022). The campaigns involved a total of 16 assessment points of covered (Sabat) and non-covered stops using a set of portable weather station TESTO 480. Results revealed the potential of Sabat in generating transient thermal aeraulic conditions within the street, and the significance of air temperature and shade in channeling wind inside Sabats. Air temperature, mean radiant temperature and relative humidity significantly differ between Sabats and non-covered spaces. The wind speed recorded the largest variation. Important spatial transitions may result in abrupt thermal aeraulic transients. Although current results are limited to warm winter conditions, findings contribute to a better understanding of the use of shade and wind patterns in mitigating prolonged heat exposure and highlight the potential of Sabat space, a traditional sustainable device, in creating restorative conditions for walking activity.

© 2023 The Authors. Published by IEREK Press. This is an open-access article under the CC BY license (https://creativecommons.org/licenses/by/4.0/). Peer review is under the responsibility of ESSD's International Scientific Committee of Reviewers.

Keywords

Walkability; Transient conditions; In-between; Recovery; Thermal walk; Casbah; Resilience

1. Introduction

Cities are already experiencing the effect of climate change, especially in the Mediterranean region where significant temperature increase is being observed. Large cities are expected to witness a temperature increase of 1.5°C by mid 21st century (Revi et al., 2014). This trend is further exacerbated in urban areas due to the effect of urban heat island (UHI) and is expected to reach up 5°C temperature increase based on unchanged current greenhouse emissions (Revi et al., 2014).

Temperature rise is affecting both the microclimate and the people, resulting in more frequent hot days, heat waves, and prolonged warm conditions. Consequently, outdoor activities and pedestrian's well-being are threatened. Prolonged exposure to excessive solar radiation heat and absence of shading breaks impair the walking experience and pedestrian's health, leading to serious heat-related risks, i.e., thermal exhaustion and cardiovascular diseases (O'Malley et al., 2014). Beside the climate, walking activity is strongly related to durations of exposure to solar radiation and the required energy to absorb it, which could add a thermal load supplementary to the energy consumed during the walking process. Investigating climate adaptive solutions is becoming mandatory to guarantee present and future healthy environments.

Improving resilience has been widely cited as a primary goal to tackle challenges related to urban heat increase, encouraging both mitigation and adaptation strategies in cities. Resilience stands for the ability to absorb a major shock with the capacity of effective recovery and normal continuity (Leichenko, 2011). In the urban context, the challenge of urban planners is to develop resilient strategies capable of facing the ongoing threats of climate change. In more recent applications in urban sustainability, resilience is understood to require flexibility, learning, and change (Tyler & Moench, 2012). In this perspective, the term resilient is used to highlight the need to design urban spaces able to adapt to a wider range of urban heat in order to absorb, tolerate, and recover from discomfort conditions.

Under such increasingly hot conditions, many studies are developing climate-responsive strategies under the heat-resilient framework (He et al., 2021). Heat mitigation strategies are focused on heating reduction and enhancing cooling sources through urban greenery, water bodies, and shading structures. While heat mitigation is important, the need for more adapted solutions has become crucial to face current and upcoming temperature rises. On the other hand, heat adaptation strategies involve taking advanced measures considering the interplay between individuals and their environmental adaptability. After accessing the urban heat patterns, individuals may prefer to change their outdoor activity or reschedule the time to avoid extreme hours (He et al., 2021). Outdoor adaptive devices could be also used to screen solar radiation during extreme periods and allow its exposure in ordinary conditions (Tomasi et al., 2022). Furthermore, the use of adaptable devices or spatial configurations can enhance environmental flexibility, ensuring a diverse range of climate-responsive solutions that vary regularly, whether on a daily or seasonal basis.

Environmental diversity in urban areas also plays an important role in providing adaptive possibilities to enable tolerance and recovery from thermal stress (Nikolopoulou & Steemers, 2003). Moreover, environmental diversity helps us rethink the process of urban design as adaptive and dynamic, featuring interplays between individuals and their environments. Although this may not reduce the totality of heat exposure, it is the most effective approach to enhance pedestrians' comfort by adopting behavioral and configurational transients that would enhance the resilience and adaptability of urban areas. Such increase in adaptive capacity can offer opportunities to experience alliesthesia (de Dear, 2011; Cabanac, 1971) and psychological adaptation (Nikolopoulou & Steemers, 2003) which enable the "training" of the capacity to recover. (Schweiker, 2020).

The current study is a part of a large research investigating the influence of transient thermal aeraulic conditions of in-between (i.e., transitional or semi-outdoor) spaces on pedestrians' walking experience in Mediterranean cities. The present work refers to environmental diversity to investigate climate-adaptive strategies to promote walkability, an essential factor influenced by the global warming impacts and could significantly reshape the course of its magnitude. The "Sabat" space (discussed below) in this study will be considered as an adaptive device capable of generating environmental diversity. Specifically, its transient thermal aeraulic conditions within the street are investigated, in the context of Algiers Casbah (Algeria). Thermal walks were carried out to capture the change in pedestrians' thermal sensation, simultaneously, with mobile micrometeorological monitoring within two preselected walking routes in Algiers' Casbah.

2. Literature review

2.1 Transient conditions

Environmental diversity is associated with the notion of passage from one space to another. It is the variation of environmental stimuli generated by the creation of one or several transition zones between the inside and the outside (Potvin, 1996). The experience of walking is related to diversity as it is a dynamic movement with transient or constant rhythm in urban areas. Recent research has sparked an interest in the significance of investigating pedestrians' dynamic thermal sensation in response to transient environmental conditions (Lau et al., 2019; Liu et al., 2021; Chun & Tamura, 2005; Qi et al., 2021, Dzyuban et al., 2022; Peng et al., 2022). These studies suggested that diversity, within a certain range of variation, is desirable to exercise adaptive capacities.

While several studies have been conducted to investigate the transient conditions of transitional spaces for long-term occupancy (Sinou and Steamers, 2004; Pitt et al., 2013), there is still a scientific gap in understanding the impact of these spaces for short-term exposure, the case of the walking activity.

2.2 The "Sabat" space, what is it?

2.2.1 Semi-outdoor space

Semi-outdoor (or semi-enclosed) space is defined as an "in-between" transitional space that, in the absence of mechanical devices, mediates between indoor and outdoor conditions such as arcades, covered balconies, porches, and galleries (Chun (& Tamura, 2005, Gamero-Salinas et al., 2022). Thus, creating microclimate thermal conditions in front of buildings (Sinou et al., 2004). The significant distinction of this in-between space from the outdoor space is that the latter is exposed to outdoor climate whereas the former is sheltered. According to its spatial attributes, the semi-outdoor space may create transient conditions and generate environmental diversity (Sinou & Steemers, 2004b).

In the literature, Semi-outdoor spaces are classified according to their degree of enclosure (Sinou et al., 2004) and attachment to the building (Sinou et al., 2004; Chun & Tamura, 2005; Pereira et al., 2019), into 3 main types: type 1 contained with the building with one opening (porch, entry atrium); type 2 attached to the building with two or three openings (arcade, covered passage, portico); and type 3 which is not attached to the building with four openings (undercroft, outdoor room, pergolas, pavilion) (Fig.1).

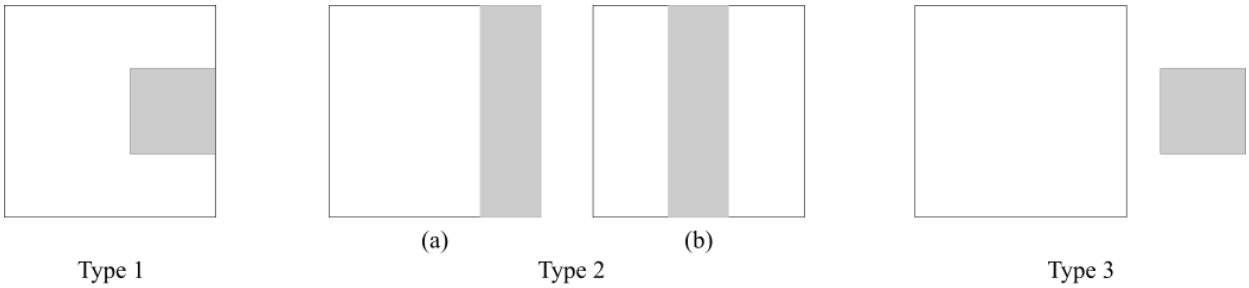

Figure 1. Three main types of semi-outdoor spaces. The shaded part in grey represents the semi-outdoor space, (a) represents the arcade while (b) represents the Sabat.

2.2.2 Definition of Sabat

The present research will focus on type 2, the covered passage, which is also called "Sabat" in North African cities, and "Archo" in Italian cities. The "Sabat" space is a type of semi-outdoor space well spread in the Mediterranean region. Architecturally, is a lift-up building design within the street resulting in a covered passage elevated by the structural walls of the street's opposite buildings. The difference between an arcade (Fig.1. a) and a Sabat (Fig.1. b) is that the latter has only two opposite openings.

Originally, the Sabat is an Arabic term that refers to a device that allows the creation of additional space attached to a building and bridging the public right-of-way, creating a covered passage (Hakim, 2008). This type of space is well spread across the Mediterranean traditional cities in North Africa, southern Italy, and Eastern Mediterranean towns (Fig.2). It is suggested that Sabat originated from the need to extend houses when there is no free space on the ground floor in north African traditional towns. The requirement to sustain structures and avoid seismic damage in southern Italy may also be one of the reasons to use the Sabat and arches as support systems.

Despite the existing literature on the environmental performance of semi-outdoor spaces in generating microclimates for both indoor and outdoor environments (Sinou and Steamers, 2004; Chun & Tamura, 2004; Pitt et al., 2013) to the best of the author's knowledge no investigations exist that approach the potential use of Sabat space and its significance in creating environmental diversity.

Algiers Casbah (Algeria) Ostuni, Puglia (Italy) Bari Vecchia, Puglia (Italy)

Figure 2: Examples of Sabat in Algeria (Algiers Casbah) and Italy (Ostuni and Bari Vecchia). Credit: photos taken by the author (2022). Photos demonstrate the extended room on the first flour of the housings, resulting in a covered passage. The spatial characteristics and materials used however differ between cities.

3. Methodology

3.1 Study area

The study has been carried out in Casbah, the historical city of Algiers and a UNESCO (United Nations Educational, Scientific and Cultural Organization) world heritage site since 1992. Casbah is located in north Algeria (36°47′00″N, 3° 03′37″E) at 107m, in proximity to the Mediterranean Sea. Casbah is characterized by dense urban fabric, staired streets, the absence of motorized vehicles, and the high presence of Sabat spaces, particularly in its upper part. According to Köppen–Geiger, Algiers has a Mediterranean warm temperate climate (Csa) with humid-hot summers and mild winters (Kottek et al., 2006). The Prevailing winds come from the North-Est in summer and from the North-West in winter.

The assessment points were selected to cover a variety of Sabat spaces, depending on their typology, orientation, and spatial attributes within two different walking routes. Accessibility and quality of Sabats and streets, i.e., absence of obstacles, condition, and security, were also considered. Moreover, assessment points were selected to capture the variations before and after each Sabat. The two selected walking routes are located in the neighborhood area in the upper part of Casbah. Both walking routes have the same starting point and end differently. Route 01 has a total of 350-meter walking distance with 191 stair steps. It starts at “Brahim Fateh” and ends at the boulevard “de la Victoire”, passing by “Frere Bachara” and “Boualam Bouchlaghem” pathways. It constitutes 9 street segments, 7 Sabat spaces, and 12 assessment points. Route 02 has a total of 300-meter walking distance and 186 stair steps. It starts at the secondary pathway “Brahim Fateh” and ends at the boulevard “de la Victoire”, passing by the “Frere Bachagha” and “Rabah Riyah” main pathways. It consists of 6 street segments, 4 Sabat spaces, and 10 assessment points (Fig.1).

3.2 Mobile Thermal Aeraulic Measurement

This study is based on thermal walks methodology, recently used by scholars for the aim of investigating the dynamic experience of pedestrians walking through streets with transient conditions (Vasilikou & Nikolopoulou, 2013; Liu et al., 2021; Dzyuban et al., 2022). The measurement campaigns were carried out for five days in late December (2022), under a clear sky and warm winter conditions, in 2022 and simultaneously with the questionnaire survey. The campaigns involved a total of 16 assessment points of Sabat (covered) and non-covered stops using a set of portable weather station TESTO 480. The data was gathered from 1 p.m. to 4 p.m. with an interval of 1h30 and 7-minute ‘stopping time’ (Qi et al., 2021; Peng et al., 2022). Air temperature (Ta), relative humidity (RH), solar radiation (Tg), and wind speed (Ws) were the main collected data during the survey due to their relevance to outdoor pedestrian comfort. Data analysis was based on the mean value of the last 3-minute assessment (data was recorded each minute for 7 minutes). Wind speed is reported as the highest recorded value during the assessment time.

A set of portable weather stations was tailored by the author for the mobile measurements. It consists of the digital multifunction TESTO 480 with a vane probe (Ø 16 mm) with a telescope (960mm) to measure Wind speed (Ws), Humidity and temperature probe (Ø 12 mm) for Air temperature (Ta) and Humidity (RH), and a black globe probe (Ø 150mm) with 0.95 emissivity, TC Type K, to measure Globe temperature (Tg). The TESTO 480, the vane probe, and the humidity and temperature probe were fixed on a camera tripod at a height of 1.40 m. the wind speed probe

was extended to reach 1.70 m Height to simulate the average height of a walking person. The globe probe was fixed in a second camera tripod and was kept 1 meter distant from the first tripod to avoid potential radiation from the instruments.

3.3 Pedestrian thermal sensation

Since Casbah is known for its staired street character due to the inadequate topography, walking upward the staired streets was the selected direction for the current study to investigate the least satisfied conditions for the walking activity (Fig.1). A total of 20 adult participants aged between 20 and 45 years old (6 males and 14 females) agreed to participate through an online Call of research participants. Each walk consisted of 1 - 3 participants with a total of 13 walks. Participants were gifted with Casbah sticker magnets pack at the end of the walk. Upon meeting participants, they were introduced to the questionnaire and were advised to provide individual, quick, and conscious responses at each survey point. Participants rested for 10 minutes upon starting the thermal walk. At each survey point, participants recorded their thermal sensation vote (TSV) for the environment according to the ASHRAE seven-point scale with cold (− 3), cool (− 2), slightly cool (− 1), neutral (0), slightly warm (+ 1), warm (+ 2), and hot (+ 3).

3.4. Data analysis

Collected data was processed and analyzed using IBM SPSS version 29.0.0.0. The statistical tests were selected to confirm the following hypothesis: Thermal aeraulic conditions differ between, Sabats and non-covered stops creating transient thermal aeraulic conditions (1); TSV differs between Sabats and non-covered stops (2). Descriptive statistics were used to describe the variation in thermal aeraulic conditions between routes and between Sabats and non-covered stops (1). Since the data exhibited non-normal trends (normality distribution histograms), a non-parametric Kruskal Wallis test was conducted to detect the variance in the thermal aeraulic conditions among Sabats and non-covered stops within among total assessed points on one hand (2); and the variance in TSV on the other hand (2).

4. Results and discussion

The result section reports the mobile meteorological measurement of the Casbah thermal walks with the aim of exploring the potential of Sabat in generating transient thermal aeraulic conditions. Kruskal Wallis test revealed significant insights (Fig.3) among the total 16 assessment points (8 Sabats and 8 non-covered spaces). The significance level was set to .05.

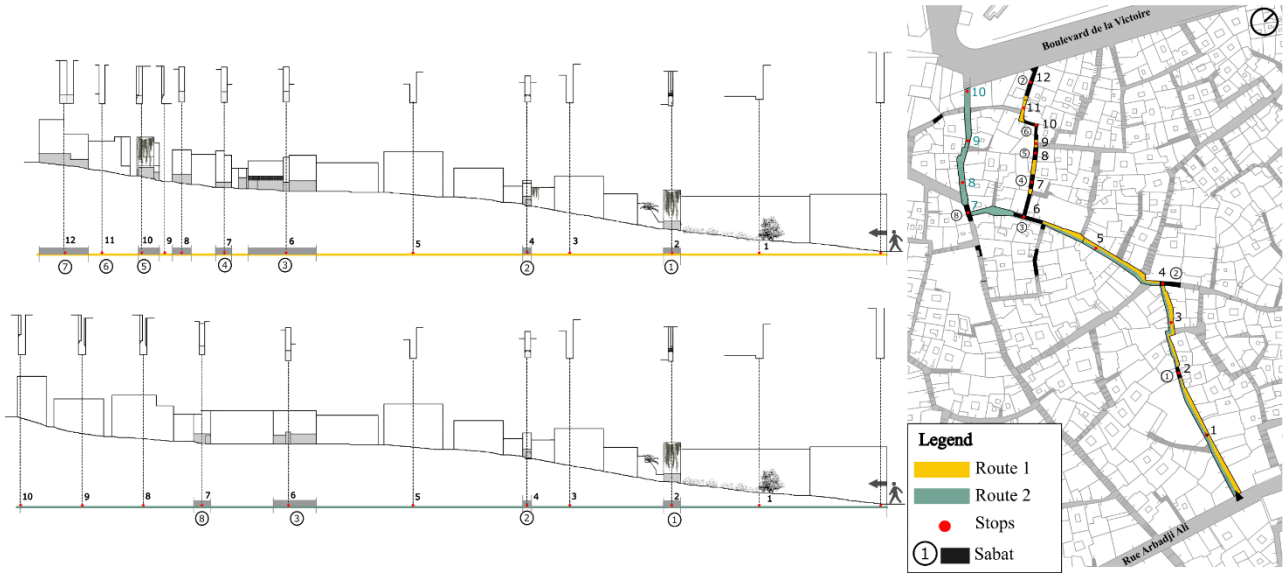

Figure 3: Two selected walking route and the 16 assessment stops on the left. Graphical section of the two walking routes that shows the significant presence of staired streets and position of Sabats.

4.1 The influence of Sabat space in creating transient thermal aeraulic conditions

Both (Ta) and (Tg) were significantly higher in non-covered stops (Ta: H (1) = 6.353, p = .012; Tg: H (1) = 6.914, p = .009) (Fig.3.a). Ta reached its peak values at Sabat 7 (24.7°C) in Route 1, and at stop 10 (23.9°C) in Route 2, while Sabat 4 recorded the lowest Ta (18.5°C) and Tg (18.9°C). Tg was also higher at Sabat 7 (25.2°C) in Route 1, and at

stop 10 (23.7°) in Route 2 (Fig.2). Lower Ta and Tg inside Sabats can be explained by the shade provided by its surface coverage. The shaded area reduced the amount of direct solar radiation exposure and allowed for lower air temperature. In addition to shade, the position of Sabat within narrow streets with reduced sky view factor resulted in reducing direct solar radiation exposure. In contrast, Sabat 7 was the warmest among Sabats due to its N-W orientation and its location between a narrow street and a wide main street (N-W). the marginal exposure to N-W low and direct exposure between 1 pm to 4 pm allowed for more heat absorption. The vertical enclosure of Sabat resulted in slower heat release through convection which resulted in warmer air temperature (Sinou & Steemers, 2004), suggesting that Sabats exposed to direct solar exposure tend to trap temperature during warm winter conditions.

Figure 3.a. shows that among total assessment points, there was no significant difference in Ws ($H(1) = 1.34317$, $p = .246$). However, Ws exhibited a large distribution downward at the bottom of the boxplot while the median was shifted to the upper part of the boxplot, indicating a large variation in wind speed among Sabat spaces. Wind speed reached a maximum value of (1.1m/s) at Sabat (1) and Sabat (7) and a minimum value of 0 m/s at Sabat 6 (Fig.2). Moreover, descriptive statistics in Figure 2 showed an increase in wind speed at each Sabat followed by a decrease in non-covered, with the exception of Sabats oriented WNW-ESE (Sabat 4, 5, and 6) where Ws tended to decrease and reached its lowest value at Sabat 6. After eliminating Sabats (4), (5), and (6) from the analysis, Ws significantly varied between Sabat and non-covered stops ($H(1) = 6.617$, $p = .010$). (Fig.3.b). Such results reveal the potential of Sabat space to generate wind acceleration despite the compact urban layout of Casbah. The wind channeling inside Sabat could be explained by an aeraulic (Mechanical) behavior and a thermal.

4.1.1 Aeraulic behavior

Following the prevailing winds, the acceleration inside the Sabat could be explained by the "channeling effect" inside its lift-up design within the narrow streets. One reason is the mechanical nature of the wind flow which passes directly through the lift-up area (Du et al., 2017). When wind moves through narrow passages between buildings, it tends to accelerate due to the channeling effect (Stathopoulos et al., 1992) and its magnitude is related to building size and configuration, distance, and orientation. In the case of lift-up buildings, such as Sabat or a passageway, wind passes at high speed through the openings (Lawson & Penwarden, 1975). However, Sabat 4, 5, and 6 exhibited the lowest wind speed despite following the same orientation of the prevailing winds. This could be explained by the short distance between the 3 Sabats and the low height of the void underneath (2 meters). Such results go along with Chew et al., (2019) findings, where 10 simulations were conducted of lift-up buildings of different void heights while maintaining the same width between buildings of 15 canyons. Authors suggested that a 2m void height is insufficient to channel wind speed, void height of 4 m is sufficient for maintaining high pedestrian-level wind speeds along the street, while there was no significant difference for further increase of 4-6 m. These findings suggest that for dense and low Sabats, wind flow may be slowed down by the downwash effect from the windward face of downstream Sabat in comparison to the first one. Although a single low Sabat may allow wind acceleration, the wind flow may lose its stream-wise momentum at the nearest opening of the Sabat.

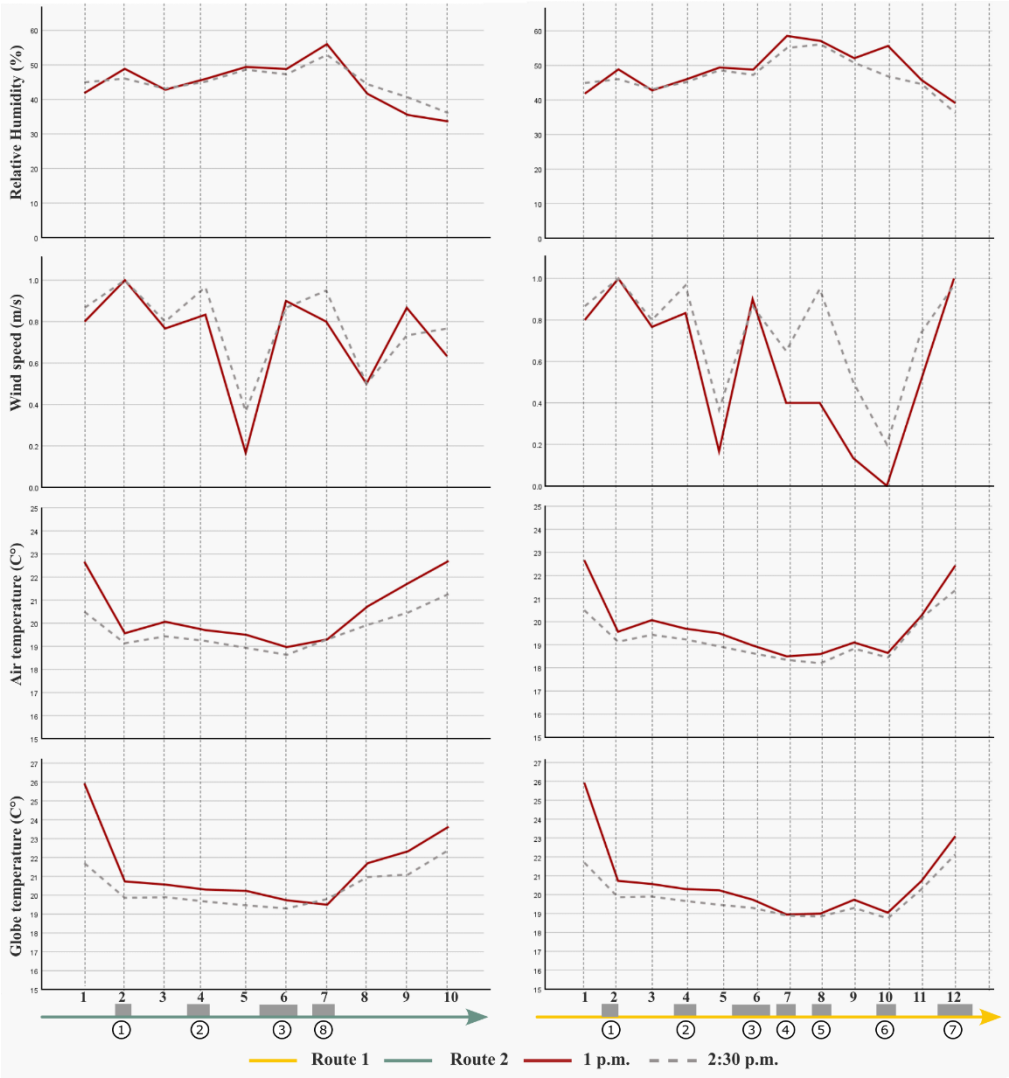

Figure 4: Variation of the meteorological measurement recorded during 5 days in December 2022. Measurement stops and position of Sabats are also denoted.

4.1.2 Thermal behavior

Thermal heating plays an important role in controlling wind flow within urban areas. (Kim & Baik, 2001). Shaded Sabat is significantly cooler than the surrounding air temperature which may cause the air to create a low local-pressure zone in comparison to the surrounding environment. In accordance with (Xie et al., 2007) study, when receiving direct solar radiation in a non-covered street, the air in proximity to the ground surface was hotter than in the center of the shaded Sabat space. Because of the air temperature difference, the hot air moves along the street eventually leading to wind acceleration when reaching the Sabat. This suggests that shaded cool Sabats, in close proximity to more elevated environmental temperatures, contribute to channeling the wind flow inside the Sabat.

5. Conclusion

In this study, the potential of Sabat spaces in generating transient thermal aeraulic conditions within the streets was investigated using mobile meteorological measurement during 5 warm winter days in December 2022. The results show that there is a significant variation in thermal aeraulic conditions between Sabats and non-covered streets. Air temperature and relative humidity significantly differ between Sabats and non-covered spaces. The wind speed recorded the largest variation. The difference in variations could be related to the spatial attributes (i.e., height) of the Sabat space, position, orientation, and the conditions of its surrounding environment. Important spatial transitions may result in abrupt thermal aeraulic transients. Furthermore, results reveal the significance of Sabat thermal-aeraulic behavior in creating a wind channeling effect inside Sabats. Although current findings are limited to warm winter conditions, they contribute to a better understanding of the use of shade and wind patterns in mitigating prolonged

heat exposure and highlight the potential benefits of using Sabat spaces in urban design, as an adaptable device, to improve thermal comfort and wind flow. Further research is needed to address the effectiveness in different contexts and seasonal conditions.

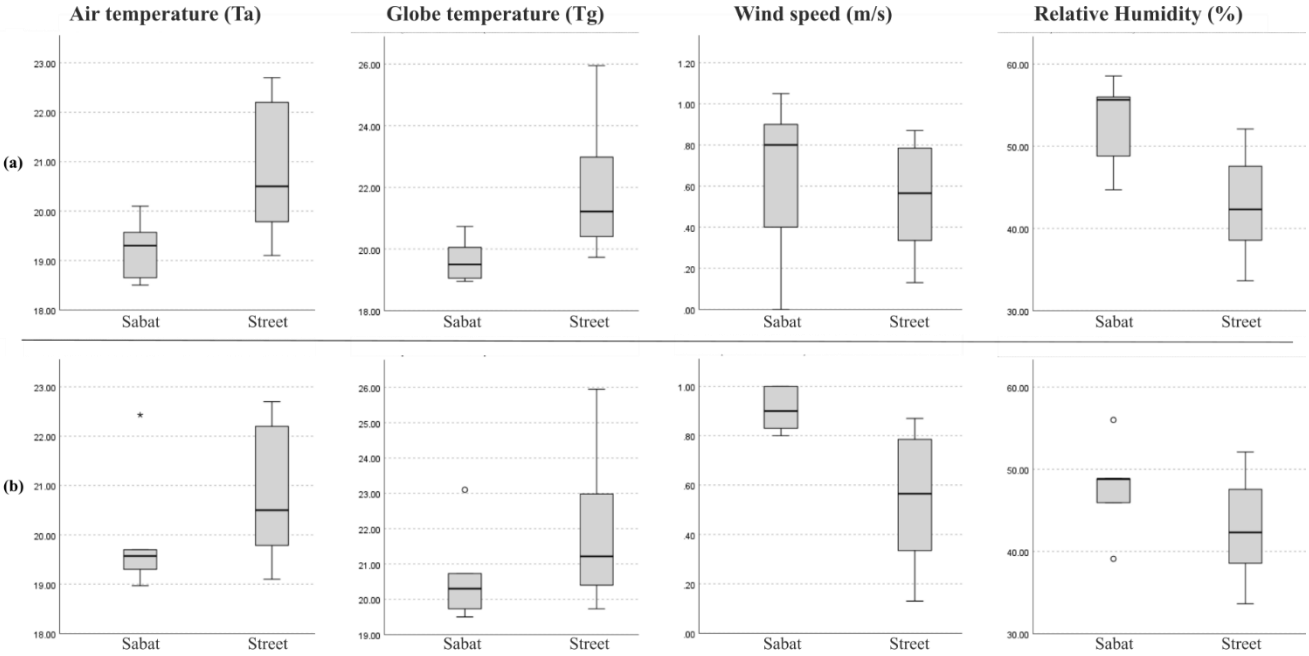

Figure 5: Box plots showing the distributions inTa, Tg, m/s and Rh between Sabat and covered streets / Kruskal Wallis analysis results showing the significant variation among total assessment stops (a). Kruskal Wallis analysis results after removing Sabat 4, 5, and 6 from the analysis input, highlighting the significance different in Ws among Sabats and non-covered streets (b)

Acknowledgments

The abstract of this paper was presented at the Urban Planning & Architectural Design for Sustainable Development (UPADSD) Conference – 8th Edition which was held on the 24th-26th of October 2023.

Funding declaration:

This research did not receive any specific grants from funding agencies in the public, commercial, or not-for-profit sectors/individuals.

Ethics approval:

Not applicable.

Conflict of interest:

The authors declare that there is no competing interest.

References

Cabanac, M. (1979). Sensory pleasure. The quarterly review of biology, 54(1), 1-29. https://doi.org/10.1086/410981

Chew, L. W., & Norford, L. K. (2019). Pedestrian-level wind speed enhancement with void decks in three-dimensional urban street canyons. Building and Environment, 155, 399-407. https://doi.org/10.1016/j.buildenv.2019.03.058

Chun, C., & Tamura, A. (2005). Thermal comfort in urban transitional spaces. Building and Environment, 40(5), 633-639. https://doi.org/10.1016/j.buildenv.2004.08.001

De Dear, R. (2011). Revisiting an old hypothesis of human thermal perception: alliesthesia. Building Research & Information, 39(2), 108-117. https://doi.org/10.1080/09613218.2011.552269

Du, Y., Mak, C. M., Liu, J., Xia, Q., Niu, J., & Kwok, K. C. (2017). Effects of lift-up design on pedestrian level wind comfort in different building configurations under three wind directions. Building and Environment, 117, 84-99. https://doi.org/10.1016/j.buildenv.2017.06.036

Dzyuban, Y., Hondula, D. M., Vanos, J. K., Middel, A., Coseo, P. J., Kuras, E. R., & Redman, C. L. (2022). Evidence of alliesthesia during a neighborhood thermal walk in a hot and dry city. Science of the Total Environment, 834, 155294. https://doi.org/10.1016/j.scitotenv.2022.155294

Gamero-Salinas, J., Kishnani, N., Sanchez-Ostiz, A., Monge-Barrio, A., & Benitez, E. (2022). Porosity, openness, and exposure: Identification of underlying factors associated with semi-outdoor spaces' thermal performance and clustering in tropical high-density Singapore. Energy and Buildings, 272, 112339. https://doi.org/10.1016/j.enbuild.2022.112339.

Hakim, B. S. (2008). Mediterranean urban and building codes: origins, content, impact, and lessons. Urban Design International, 13(1), 21-40. https://doi.org/10.1057/udi.2008.4

He, B. J., Zhao, D., Xiong, K., Qi, J., Ulpiani, G., Pignatta, G., ... & Jones, P. (2021). A framework for addressing urban heat challenges and associated adaptive behavior by the public and the issue of willingness to pay for heat resilient infrastructure in Chongqing, China. Sustainable cities and society, 75, 103361. https://doi.org/10.1016/j.scs.2021.103361

Kim, J. J., & Baik, J. J. (2001). Urban street-canyon flows with bottom heating. Atmospheric Environment, 35(20), 3395-3404. https://doi.org/10.1016/S1352-2310(01)00135-2

Kottek, M., Grieser, J., Beck, C., Rudolf, B., & Rubel, F. (2006). World map of the Köppen-Geiger climate classification updated. Meteorologische Zeitschrift. Vol. 15, No. 3, 259-263. https://doi.org/10.1127/0941-2948/2006/0130

Lau, K. K. L., Shi, Y., & Ng, E. Y. Y. (2017). Dynamic response of pedestrian thermal comfort under outdoor transient conditions. International Conference on Urban Comfort and Environmental Quality, 69-75. Genova University Press. https://doi.org/10.1007/s00484-019-01712-2

Lawson, T., & Penwarden, A D. (1975). The effect of wind on people in the vicinity of buildings. In 4th Int. Conf. on Wind Effects on Buildings and Structures, London, 1975. Cambridge University Press. 605-622.

Leichenko, R. (2011). Climate change and urban resilience. Current opinion in environmental sustainability, 3(3), 164-168. https://doi.org/10.1016/j.cosust.2010.12.014

Liu, S., Nazarian, N., Hart, M. A., Niu, J., Xie, Y., & de Dear, R. (2021). Dynamic thermal pleasure in outdoor environments-temporal alliesthesia. Science of The Total Environment, 771, 144910. https://doi.org/10.1016/j.scitotenv.2020.144910

Nikolopoulou, M., & Steemers, K. (2003). Thermal comfort and psychological adaptation as a guide for designing urban spaces. Energy and buildings, 35(1), 95-101. https://doi.org/10.1016/S0378-7788(02)00084-1

O'Malley, C., Piroozfarb, P. A., Farr, E. R., & Gates, J. (2014). An investigation into minimizing urban heat island (UHI) effects: A UK perspective. Energy Procedia, 62, 72-80. https://doi.org/10.1016/j.egypro.2014.12.368

Pereira, C. M., Heitor, T. V., & Heylighen, A. (2019). Exploring Multisensory Qualities of Loggia Spaces for Urban Resilience to Climate Change. Modular Journal, 2(2), 1-20. http://modular.gedik.edu.tr/en/pub/issue/53021/701755

Peng, Z., Bardhan, R., Ellard, C., & Steemers, K. (2022). Urban climate walk: A stop-and-go assessment of the dynamic thermal sensation and perception in two waterfront districts in Rome, Italy. Building and Environment, 221, 109267. https://doi.org/10.1016/j.buildenv.2022.109267

Pitts, A. (2013). Thermal comfort in transition spaces. Buildings, 3(1), 122-142. https://doi.org/10.3390/buildings3010122

Potvin, A. J. A. (1997). Movement in the architecture of the city: a study in environmental diversity (Doctoral dissertation, University of Cambridge).

Qi, Q., Meng, Q., Wang, J., & Ren, P. (2021). Developing an optimized method for the 'stop-and-go'strategy in mobile measurements for characterizing outdoor thermal environments. Sustainable Cities and Society, 69, 102837. https://doi.org/10.1016/j.scs.2021.102837

Revi, A.; Satterthwaite, D.E.; Aragón-Durand, F.; CorfeeMorlot, J.; Kiunsi, R.B.R.; Pelling, M.; Roberts, D.C.; Solecki, W. Urban areas. In Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (p. 535–612). Cambridge University Press. https://doi.org/10.1017/CBO9781107415379

Schweiker, M. (2020). Rethinking resilient comfort—Definitions of resilience and comfort and their consequences for design, operation, and energy use. In Proceedings of the 11th Windsor Conference: resilient comfort. 34-46

Sinou, M., & Steemers, K. (2004). Urban semi-enclosed spaces as climate moderators. In Proceedings of PLEA 21st Conference on Passive and Low Energy Architecture.385-389.

Sinou, M., & Steemers, K. (2004b). Intermediate space and environmental diversity. Urban design international, 9, 61-71. https://doi.org/10.1057/palgrave.udi.9000113

Stathopoulos, T., & Wu, H., & Bédard, C. (1992). Wind environment around buildings: a knowledge-based approach. Journal of Wind Engineering and Industrial Aerodynamics, 44(1-3), 2377-2388. https://doi.org/10.1016/0167-6105(92)90028-9

Tomasi, Marika; Nikolopoulou, Marialena; Giridharan, Renganathan; Romero, Juan Carlos; Löve, Monika; Ratti, Carlo. Walkability and Solar Radiation Exposure for Diverse Users: Climate-responsive Urban Design to enhance accessibility to outdoor spaces (2022). In Proceeding of the 36th PLEA conference 2022: Will cities survive? The future of sustainable buildings and urbanism in age of emergency. vol 2, 687-692

Tyler, S., & Moench, M. (2012). A framework for urban climate resilience. Climate and development, 4(4), 311-326. https://doi.org/10.1080/17565529.2012.745389

Vasilikou, C., & Nikolopoulou, M. (2013). Thermal walks: identifying pedestrian thermal comfort variations in the urban continuum of historic city centers. In Proceeding of PLEA2013-29th Conference, Sustainable architecture for a renewable future, Munich, Germany. 10-12.

Xie, X., Liu, C. H., & Leung, D. Y. (2007). Impact of building facades and ground heating on wind flow and pollutant transport in street canyons. Atmospheric Environment, 41(39), 9030-9049. https://doi.org/10.1016/j.atmosenv.2007.08.027