Outdoor Thermal Comfort in Public Open Spaces: Examples of Taksim Square and Gezi Park, Istanbul

Public open spaces are significant design elements to create a sustainable urban environment that are the common intersection of society, support urban life and breathe the city by hosting daily pedestrian traffic and various outdoor activities with their physical, ecological, economic, political and socio-cultural values. These open spaces, which consist of compositions of natural and built environment components, have various microclimatic conditions with the spatial differences created by the varied landscape elements such as vegetation, surface material and urban furniture they contain. These microclimatic conditions are also influenced by many environmental factors such as the dimensions, geometries, orientations and materials of the building blocks and streets in the urban canyon. However, each micro space affects climatic components such as air temperature, relative humidity, amount of solar radiation, wind speed and direction at the local level and creates different thermal environments which cause people to feel thermally comfortable or stressed and significantly affect users' comfort. While this causes specific differences in the thermal conditions perceived by the users for each specialized area; it has also impacts on the use of spaces and therefore urban vitality. In this direction, it is necessary to give importance to the thermal comfort of people in outdoor spaces in order to design today's and future public open spaces that support user health and comfort and are sensitive to the microclimate.

Thermal comfort is defined in 3 approaches as especially thermophysiological, based on the heat balance of the human body and psychological that develop over each other. In the thermophysiological approach, thermal comfort is expressed as a minimum of nerve signals coming from thermal receptors in the brain (hypothalamus) and skin, which are sensitive to temperature changes. Accordingly, under comfort conditions, the internal body temperature is 37°C and the average skin temperature is in a narrow range of 33-34°C, and intense physiological reactions such as sweating or shivering do not occur. According to the definition of heat balance, thermal comfort is the situation in which the heat flows entering and leaving the human body are balanced and the skin temperature and sweat ratio remain within certain ranges depending on the metabolic activity. In this case, the person does not prefer the warmer or colder ambient temperature and feels thermally neutral. This approach is based on Fanger's (1970) scaled rational model, which basically includes the physiological regulation of body temperature in a limited range with environmental conditions, and this model forms the basis of many standards used in thermal comfort calculations today. In the more comprehensive psychological approach, thermal comfort is the state of mind that expresses the satisfaction of the person with the thermal conditions of the environment. Accordingly, thermal comfort, which is subject to a subjective evaluation, is a cognitive process that is affected by the psychological state and many other factors beyond the physical or physiological structure of the person. Therefore, it is not possible to create comfortable environmental conditions for everyone in a given area, as the thermal sensation may differ from person to person, whether indoor or outdoor. For this, it is necessary to define conditions that at least 80% of users will find comfortable in typical applications according to ASHRAE Standard-55.

There are 6 main parameters to be considered when defining thermal comfort conditions. These parameters which were determined by Fanger (1967) according to the heat balance of the human body, consist of climatic factors such as air temperature, mean radiant temperature, wind speed and relative humidity, and personal factors such as metabolic rate and clothing insulation. Apart from these, there are a number of secondary factors that affect thermal comfort such as socio-cultural factors, past experiences, habits, expectations, exposure time, adaptation actions, health status, gender or body type. To date, approximately 165 thermal indices have been developed to calculate thermal comfort for indoors and outdoors including both experimental indices such as Wind Chill Index (WCI), Discomfort Index (DI) and heat balance-based analytical indices such as Predicted Mean Vote (PMV), Physiological Equivalent Temperature (PET), Perceived Temperature (PT), Standard Effective Temperature (SET), Universal Thermal Climate Index (UTCI).

Although thermal comfort has been a scientific research topic since the beginning of the 20th century, initially studies focused on indoor thermal comfort for a long time, especially in order to determine building design and usage standards. In this context, extensive research has been carried out on the climatic conditions inside the buildings and the comfort perceptions of the building occupants through the developed indices, and the outdoor thermal comfort has been neglected until recently. Thermal comfort studies, which increased mostly within the scope of military applications during the Second World War, started to be the research topic of many disciplines such as physiology, public health, geography, climatology as well as engineering after the war. Olgyay (1963) brought the phenomenon of thermal comfort to the discipline of architecture by bringing together and interpreting the findings of various disciplines. In this context, the comfort zone is defined as the conditions in which a person spends minimum energy to adapt himself to his/her environment; it has been emphasized that the quality of life and productivity of people increase in conditions where thermal balance is provided. Thus, Olgyay, who synthesized the elements of human physiology, climatology and building physics, became the advocate of bioclimatic architecture by emphasizing the importance of regional conditions and environmentally sensitive design. However, due to the urgent need to reduce the economic and environmental costs of energy consumption, thermal comfort, which has been studied for a long time in indoor spaces such as offices, schools, houses and later in closed vehicle environments, has started to be investigated in open spaces within the scope of sustainable urban planning in the following years.

Along with the increasing pressure of urbanization on open spaces, ecological deterioration and climate change, the studies on outdoor thermal comfort have increased in addition to the studies of urban climate and microclimatic sensitive design, especially in the last 20 years. In this context, field studies and simulation studies based on modeling software have been carried out in various city squares, city parks, streets, open areas around the buildings in different geographical and climatic locations. However, there is still a lack of original data in outdoor thermal comfort studies, which aim to determine the outdoor microclimatic conditions and thermal stress categories and to provide appropriate thermal comfort conditions for individuals in the outdoor environment. Studies conducted especially in Turkey still lack field-specific data and their number is quite limited. In addition, particular thermal perception categories and comfort ranges developed by Matzarakis & Mayer (1996) for Western and Central Europe are mostly taken as references in the analysis of the thermal comfort conditions of the outdoor environment. However, the climate zone in which each city is located and the climatic, environmental and socio-cultural components of each region within the city differ. This situation highlights the need to use original data to be obtained from both subjective and objective measurements in outdoor thermal comfort studies.

This study aims to define summer outdoor thermal comfort conditions and thermal perception categories by emphasizing the variability of microclimatic conditions in Taksim Square and Gezi Park in Istanbul, a hot-humid city with urban heat problems. There are 4 main hypotheses of this study as 1) Climatic parameters and environmental parameters are interrelated and create different microclimatic conditions in public open spaces. 2) Different microclimatic conditions vary in users' thermal perceptions. 3) Climatic parameters, environmental parameters and user-related parameters affect outdoor thermal comfort. 4) Site-specific data should be used to determine the outdoor thermal comfort range and thermal stress categories of a region.

In this context, after a literature review using the concept of outdoor thermal comfort, which is the main subject of the study, and keywords such as urban climate, urban climatology, microclimate, thermal comfort, bioclimatic comfort, human bioclimatology, thermal perception, thermal sensitivity, thermal stress; firstly, Taksim Square and Gezi Park, one of the most heavily used public open spaces of Istanbul, and 2 locations from each urban area were selected to evaluate the outdoor thermal comfort according to different landscape elements in the field study. The reason why this square and park were chosen together is both their historical background, the absence of a sharp physical boundary between these two public open spaces, the micro spaces they contain and the existence of long-term activities in these spaces. Considering climate change and hot weather events, which are one of the global and national problems of today, as well as the periodic use of these two areas, it has been decided that the study period should be the daytime summer season.

In the second stage, regional climate data from the 11 meteorological stations closest to Taksim Square and Gezi Park were obtained from the date of the oldest recording to the present. By analyzing these climatic data, the date range of 30 July – 2 August 2022, which reflects a typical summer period for the region, was determined as measurement days, and the time interval between 10:00 and 18:00 was determined as measurement hours. In the third stage, more than 400 pedestrian questionnaire surveys were conducted with users who have been in Istanbul for more than 6 months and for more than 15 minutes by measuring microclimatic parameters simultaneously with KESTREL 4500 and KESTREL 5500 portable meteorological station instruments at these date and time intervals in 4 selected locations. While measuring air temperature, relative humidity, wind speed and direction within the scope of microclimatic monitoring; personal information such as gender, height/weight, age, clothing and activity level in the last 1 hour were collected from the participants during the questionnaire survey. At the same time, participants rated their thermal sensation, thermal acceptability, thermal preference, preferences of air temperature, relative humidity, wind speed and solar radiation amounts and overall comfort using 9- and 4-point ASHRAE and 3-point McIntyre scales. In addition, environmental parameters such as plant species and sizes, surface materials, urban furniture, building heights, sky view factor in and around the site were measured to model the field area for calculating the mean radiant temperature and then outdoor thermal comfort values.

In the fourth stage, the measured microclimatic and environmental data were modeled in the INX plugin of ENVI-met software and analyzed for each questionnaire in order to calculate the mean radiant temperature, which is an important parameter for outdoor thermal comfort. In the fifth stage, the PET index (Physiological Equivalent Temperature) was selected for the thermal comfort calculations of this study because it represents the outdoor thermal conditions well and provides ease of comparison thanks to its values in °C. The PET values were determined for each participant by using ENVI-met.INX model, simulated Tmrt values and personal information from the questionnaire in ENVI-met software. In the sixth step, a regression line was used to determine the neutral and preferred PET ranges based on the questionnaire responses that included scale ratings. As a result, the thermal perception scale for the summer period of the study area was created by comparing the PET values temporally and spatially.

The findings of the study show that the 4 locations selected from Taksim Square and Gezi Park have different microclimatic conditions in line with the spatial differences they contain, and therefore they also have different thermal perception categories. Thus, it can be said that public open spaces have different microclimate conditions without exception and these conditions are perceived differently by pedestrians. At the same time, the study emphasizes the importance of site-specific determination of outdoor thermal conditions; it also shows the feature of being the first study for Istanbul that includes simultaneous objective and subjective evaluations. In addition, questioning the thermal comfort conditions of open spaces on a micro scale will enable the creation of site-specific sustainable urban policies, and will allow the creation of cities that are more resistant to climate change and heat waves, which are the most severe urban problems of today and the future.