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Original Research

Determination of Bioclimatic Comfort Structure of the Isparta City Center for Outdoor Recreation

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Abstract

In this study, the bioclimatic comfort situation of the Isparta city center was examined for outdoor recreation. It is important to determine the suitable times and days of the year for bioclimatic comfort in recreational planning. To determine the suitable times and days, one day was divided into two-hour parts (10.00-18.00), and the months were divided into 10-day periods. The climatic data belonging to the determined area were obtained by the portable weather station, and the bioclimatic comfort was evaluated using these data. The physiological equivalent temperature (PET) index was used to calculate the bioclimatic comfort conditions. Calculations of the PET index were performed by the program RayMan 2.1. The PET values were presented according to bioclimatic comfort classes by graphics of percentage distribution daily and monthly. The research results indicate that in the city center of Isparta, the most comfortable days predominantly occur at 10.00 in October (38.3%), at 12:00 in May (28.6%), at 14:00 in May and October (28.3%), at 16.00 in May (41%), and at 18.00 predominantly between June and October (36.6%). There is no comfortable interval during summer, especially in August, because of the high temperature and solar radiation. Furthermore, the climatic conditions are colder in the morning and evening and warmer in the afternoon.

Keywords: bioclimatic comfort, physiologically equivalent temperature (PET), Isparta, recreation plans

Introduction

Outdoor recreational activities play a crucial role in human life. They have positively contributed to individuals' physical and mental health, lifelong education, active citizenship, crime reduction, and socialization behavior. For this reason, people devote a valuable part of their daily lives to recreational activities [1-6].

Individuals who perform their activities outdoors are exposed to the direct influence of all climate elements, and these activities can be performed mainly to the extent that the climate elements allow. Therefore, climate emerges as one of the important components that affect the realization of these activities. The duration of outdoor activities also varies according to climate conditions, demonstrating notable fluctuation [7-10].

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When planning recreational areas, it is necessary to design comfortable areas in terms of climate. The attractiveness of a region significantly boosts people's motivation to travel; the climate is one of these attractive elements. Studies indicate that climate is prioritized by individuals when selecting a destination [13-16]. Traveling in regions with unsuitable climate conditions presents challenges; exposure to extreme heat or cold stress and ultraviolet radiation can lead to health issues [17-19]. Therefore, in recreation planning, the goal should be to determine climatic data by identifying temperature, relative humidity, radiation, and wind conditions and to improve the climate positively for the comfort and well-being of visitors." [11, 12]. Values, where climate elements do not put people under stress (heating or cooling), are comfortable values. In other words, it is a situation where bioclimatic comfort is provided.

Bioclimatic comfort status is the conditions in which a person can adapt to his environment by spending a minimum amount of energy. Humans spend a certain amount of energy to reach a state of bioclimatic comfort or to adapt to their environment [20-22]. The factors affecting bioclimatic comfort are environmental conditions and personal parameters. These are air temperature, air humidity, air movement, radiation, and personal factors, which are activity-related metabolism, heat regulation, activity level, and clothing insulation [23-27]. In addition to these basic factors, the number of hot days, weather conditions, diseases and pests caused by weather events, air pollution, and the amount of oxygen in the atmosphere affect human comfort [20, 21, 24, 28].

The province of Isparta, located in the Mediterranean region of Turkey, holds substantial recreational potential [29, 30]. Studies suggest that despite the recreational potential offered by the province of Isparta, its planning and projects lack functionality [31, 32]. For recreational planning in Isparta, it is necessary to reveal the region's bioclimatic comfort condition and to determine people's physiological responses to the climatic conditions in their environment.

The primary objective of this study is to determine the bioclimatic comfort condition for recreational planning in the province of Isparta. When calculating bioclimatic comfort, planners often lack expertise in computational methods, and working with extensive climate data is strenuous. The challenge to overcome in this study has led to the adoption of a particular approach for calculating bioclimatic comfort. This approach includes the local collection of climate data and the analysis of comfort using the Physiologically Equivalent Temperature (PET), specifically developed for outdoor spaces.

For this purpose, a portable meteorology station was strategically placed in the Akyol Cemetery to accurately obtain air temperature, wind speed, solar radiation, and relative humidity data unaffected by human activities and structures. These data were collected during the day from April to October. The PET index was employed to calculate bioclimatic comfort conditions. The resulting PET values were then distributed according to bioclimatic comfort ranges, revealing the dominant PET values in 10-day periods and determining bioclimatic comfort features for recreation planning in the Isparta city center. The main contributions of the research are as follows:

1. Comprehensive analysis of bioclimatic comfort in the city center of Isparta, Turkey, considering different times of the day.
2. Development of a hybrid method that combines existing bioclimatic comfort indexes with local climatic data to provide a more accurate assessment of outdoor recreation suitability.
3. Identification of optimal months for outdoor recreational activities based on bioclimatic comfort values, which can serve as a basis for landscape planning and outdoor recreation development.
4. Emphasis on the importance of integrating bioclimatic comfort maps into landscape planning to enhance residents' physical and mental well-being.

Literature Review

The importance of studies on bioclimatic comfort is increasing day by day. The main purpose of these studies is to demonstrate experimentally how thermal environments affect human comfort [33].

The initial studies on determining bioclimatic comfort are graphs prepared to analyze climatic comfort. The most significant of these graphs are Olgyay (1973)'s Bioclimatic Chart and Steadman (1979)'s temperature-humidity index [34, 35]. Over time, these graphs have been replaced by indices that predict using only the relative effects of a few meteorological parameters. These indices, derived from subjective estimates, are called empirical indices. The thermal perception predictions of empirical indices are limited to the geographical region or climate type in which the research is conducted [36]. Therefore, their results are incomparable and do not accurately reflect outdoor thermal comfort [37].

With the help of technological possibilities, bioclimatic comfort models have started to increase since the 1960s. With the development of the human body's energy balance models in the seventies and eighties, thermal comfort studies have made significant progress in developing rational indices [38]. Rational indices classify the numerical impacts of meteorological data on bioclimatic comfort, revealing comfortable and uncomfortable regions. They also enable the comparison of different regions in terms of climatic comfort [27, 37].

The heat balance approach has gained importance since the " Klima-Michel-Modell " was developed by Fanger (1970). Apart from Fanger's comfort equation, Höppe (1984) developed the MEMI (Munich Individual

Energy Balance Model), which provides quantitative data on individual heat flows, body temperatures, sweating rates, and skin wetness, depending on environmental conditions. Thermal indices such as the predicted mean vote (PMV) and physiological equivalent temperature (PET) have been developed from this equation based on the thermal balance of the human body.

Today, rational indices are preferred in 69% of the studies on calculating bioclimatic comfort in outdoor studies [36]. When examining the conducted studies, it is noted that for recreational planning, the indices frequently used for thermal evaluations in both hot and cold climate regions are The PET index and the Universal Thermal Climate Index (UTCI) [39]. Such as Koźmiński and Bożena (2019) [40] evaluated bioclimatic conditions for recreation using the UTCI, Peng et al. (2019) [41] utilized UTCI to determine comfort for outdoor activities in a square in Cambridge, Hamad and Oguz (2020) [42] employed the PET for outdoor recreation planning in Erbil, Iraq, and Çınar et al., (2021) [43] used the PET index in their assessment of green spaces in the city center of Fethiye.

In this study, the Physiologically Equivalent Temperature (PET) index was preferred, contingent upon the purpose of the study and factors related to data access. The climatic data acquired through the portable meteorological station used to collect local climate data in the research is suitable for evaluation with the PET index. The PET provides a strong method to predict people's physiological stress levels. PET is expressed in degrees Celsius (0), a commonly known unit [44-46]. This makes PET more understandable for those working in planning and design as an indicator of thermal stress [7, 47]. Furthermore, the ease of application is ensured since calculations with the PET index are simpler and quicker. With a thermophysiological background, PET reflects the true feeling of the climate on people, does not rely on subjective measurements, and is a universal index that can be used effectively in both hot and cold climates [48]. Matzarakis et al. [49] showed that PET can be easily calculated using the "RayMan" software [50].

Materials and Methods

Site Description

The main material of the research is the climate values of the city center of Isparta. Isparta is located between 37°45' North latitude and 30°33' East longitude. The global location of Isparta is shown in Fig. 1.

Data Collection

A portable meteorology station was used to evaluate the climatic data of the research area. The meteorology station is located in the Akyol Cemetery in the Halıkent Neighborhood (Fig. 1), located in the city center of Isparta, which is not under the influence of people and structures and will allow us to obtain climatic data most accurately. In Fig. 2, the station and location information used in the study are given.

Within the scope of the study, first, the region where the station was located was selected to determine the urban area's climate values. This area was chosen as the Akyol cemetery, which remains in the city but does not have cultural influences.

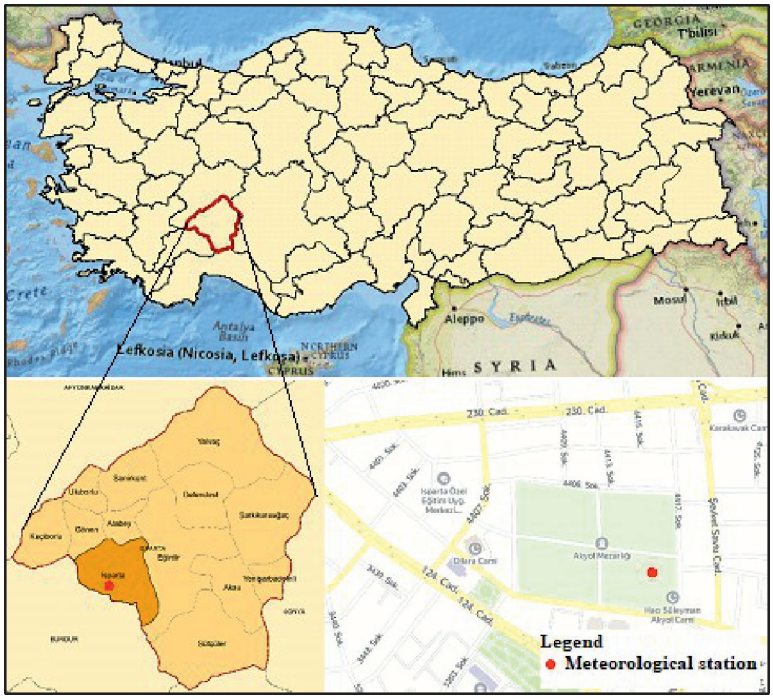

Fig. 1. The location of Isparta Province in Turkey and the meteorology station is located in the Akyol Cemetery.

Fig. 2. Portable weather station (Latitude (north) 37°45'15.34''; Longitude (East) 30°34'38.30'').

Air temperature, wind speed, solar radiation, and relative humidity data recorded at the station at 10.00, 12.00, 14.00, 16.00, and 18.00 every day until the end of April-October, which are the months people use the outdoors the most, were used. The aim here is to reveal the most suitable time zone for outdoor recreation activities that can be carried out at any time of the day.

Data Analysis

The Physiological Equivalent Temperature İndex (PET)

The physiological equivalent temperature (PET) index was used to calculate the bioclimatic comfort conditions. PET is one of the thermal indices derived by a German research group led by Peter Höppe to better predict outdoor comfort conditions, taking into account basic thermoregulation processes. The PET is based on a thermo-physiological heat balance model called the Munich Individual Energy Balance Model (MEMI) [51-55]. The basis of this model is based on the heat balance equation for the human body. have been reported and calculated as follows in Equation (1) [56].

$$M + W + R + C + ED + ERe + ESw + S = 0 \quad (1)$$

M: Metabolic rate
W: Activity type
R: Net radiation of the body
C: Convective heat flow,
ED: latent heat flow to evaporate water to water vapor emitted from the skin (imperceptible perspiration),
ERe: The sum of the heat fluxes for heating and humidifying the inhaled air,
ESw: Heat flow from evaporation of sweat,
Q: Stored heat flow to warm or cool the body.

The equation has a positive sign if it results in an energy gain for the body and a negative sign if it results in a loss of energy (M is always positive; W, ED, and Esw are always negative). The unit of all heat flux is watts. The individual heat fluxes of the equation are directly affected by the following meteorological parameters:

- Air temperature: C, ERe
- Air humidity: ED, ERe, ESw
- Air velocity: C, ESw
- Average radiant temperature: R [53].

Matzarakis and Mayer's [57] grouping in Table 1 gives the corresponding PET values regarding thermal perception and comfort [58, 59]. It allowed us to evaluate the effects of the environment on people in a physiologically meaningful way [54].

Table 1. Distribution of values in PET index and thermal sensing according to these values [25].

PET (ºC)	Thermal perception	Grade of physiological stress
<4	Very Cold	Extreme cold stress
4.1-8	Cold	Strong cold stress
8.1-13	Cool	Moderate cold stress
13.1-18	Slightly cool	Slight cold stress
18.1-23	Comfortable	No thermal stress
23.1-29	Slightly warm	Slight heat stress
29.1-35	Warm	Moderate heat stress
35.1-41	Hot	Strong heat stress
>41	Very hot	Extreme heat stress

The RayMan Model

All calculations of the PET index were made with the RayMan 2.1 program. While calculating the bioclimatic comfort conditions, the meteorological data evaluated in the RayMan program are air temperature ºC, relative humidity %, wind speed m/s, and radiation W/m^2.

PET refers to the temperature representing the human body's physiological condition, both indoors and outdoors, equaling the air temperature where the body's heat balance is kept in check in a typical indoor setting. This balance considers work metabolism (80 W of light activity), primary metabolism, and clothing heat resistance (0.9 clo), with core and skin temperatures equal to the evaluated conditions. The indoor reference climate is based on the following assumptions:

"Mean radiant temperature equals air temperature ($T_{mrt} = T_{\alpha}$)

Air velocity is set to 0.1 m/s

Water vapor pressure is set to 12 hPa (approximately equivalent to a relative humidity of 50% at T_{α} = 20ºC)" [53].

The mean radiation flux densities of the human body can be determined from the measured shortwave and longwave radiation fluxes [49]:

$$S_{str} = a_k \sum_{i=1}^{6} K_i F_i + a_1 \sum_{i=1}^{6} L_i F_i \quad (2)$$

K_i represents the shortwave (solar) radiation flux, while L_i refers to the longwave (terrestrial) radiation flux. a_k and a_1 are the respective absorption coefficients for shortwave and longwave radiation. F_i is a term that describes the angle factors of solid surfaces. After determining T_{mrt}, it can be calculated using the Stefan-Boltzmann radiation law (in ºC), where σ is the Stefan-Boltzmann constant (5.67*10-8 W/m-2 K-1) [49].

$$T_{mrt} = \sqrt[4]{(S_{str}/(a_1\sigma))} - 273.2 \quad (3)$$

Other features used when calculating bioclimatic comfort are age, gender, height, weight, isolating effect of clothing (clo), and physical activity. The standard person is a 35-year-old male, 1.75 m tall and 75 kg in weight. In addition, the clo value was taken as 0.90, and the physical activity level was taken as 80 [60, 61].

Identify The Bioclimatic Comfort Structure

PET values obtained with the RayMan model were distributed according to the bioclimatic comfort ranges, and it was revealed which PET value was dominant in 10-day periods. In the temporal distribution of bioclimatic comfort values, PET values were calculated for five different hours of each day (10.00, 12.00, 14.00, 16.00, 18.00). The frequency distributions of the obtained values according to the determined intervals are shown on the graphs. In line with the findings obtained, bioclimatic comfort features were determined for the recreation planning of the Isparta city center.

The flow chart of this study is shown in Fig. 3.

Results and Discussion

In the temporal distribution of bioclimatic comfort values, PET values were calculated for five different hours of each day (10.00, 12.00, 14.00, 16.00, 18.00). The frequency distributions of the obtained values according to the intervals determined in Table 1 are shown on the graphs in Fig. 4.

The city center is in the morning (10:00). It has been observed that the frequency of days of comfort during April is 15%. During May, the frequency of comfortable days was found to be 19%. During June, it was observed that the frequency of experiencing comfortable days was 30%. There are no comfortable days in July. There were no comfortable days during August. It was determined that the frequency of comfortable days in September was 13.3%. It was determined that the frequency of days providing bioclimatic comfort conditions during October was 38.3%.

The bioclimatic comfort situation is in the morning hours (10.00); while it was comfortable in April, May, June, September, and October, comfort was not observed in July and August. The most comfortable days were observed in October.

Within the months of evaluation, at noon (12.00), it was determined that the frequency of experiencing bioclimatic comfortable days during April was 25%. During May, the frequency of comfortable days was 28.6%. During June, the frequency of comfortable days was 23.3%. There are no comfortable days in July.

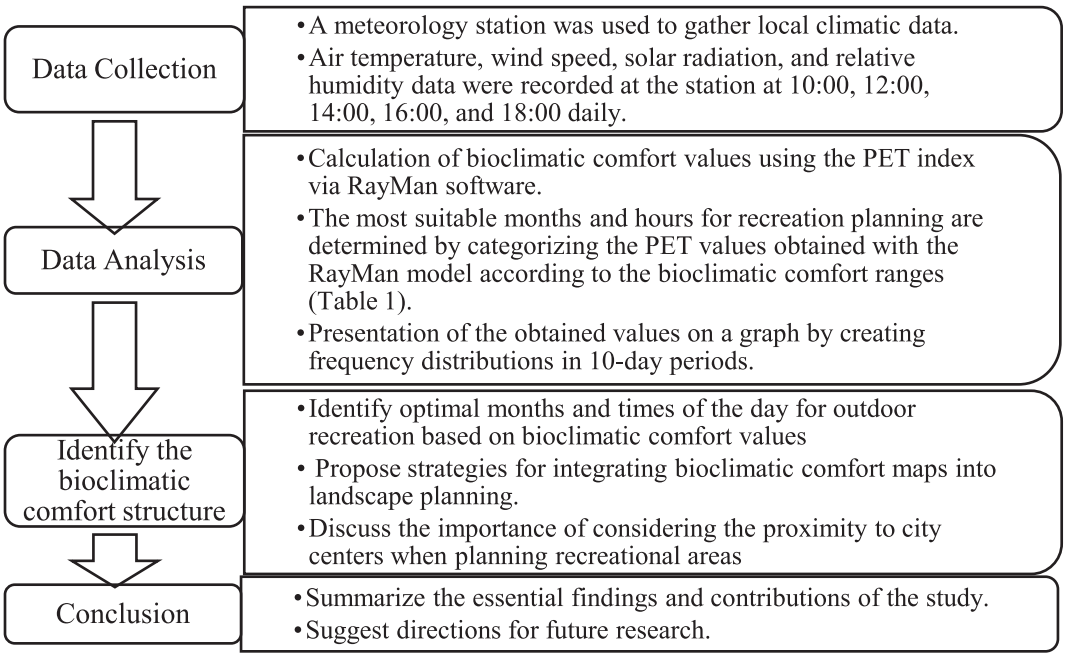

Fig. 3. Flowchart of the study.

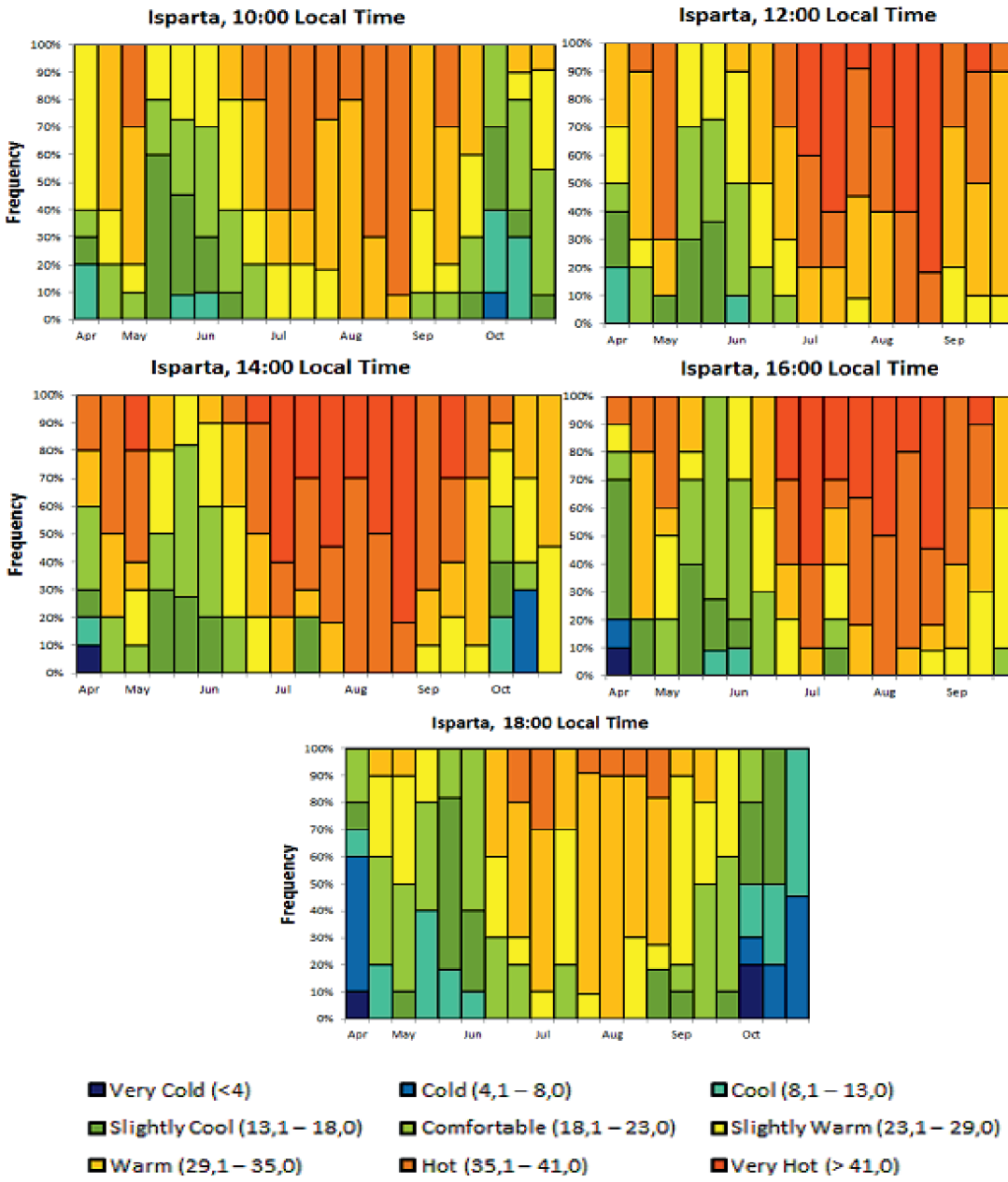

Fig. 4. Isparta city center PET distributions.

There were no comfortable days during August. There were no comfortable days during September. During October, the frequency of days providing the bioclimatic comfort condition was 22.6%. At noon (12.00), the bioclimatic comfort situation is provided in April, May, June, and October, while the bioclimatic comfort situation is not observed in July, August, and September.

Within the months evaluated, it was observed that the frequency of the days when the bioclimatic comfort status was realized during April (14.00) in the afternoon was 10%. During May, the frequency of days in the comfortable interval was 28.3%. It was observed that the frequency of comfort days was 20% during June. There were no comfortable days in July, August, and September. It was determined that the frequency of days providing bioclimatic comfort conditions during October was 28.3%. While it was observed that bioclimatic comfort was appropriate in April, May, June, and October afternoons (14.00), it was observed that bioclimatic comfort was not provided in other months where measurements were made.

Within the evaluated months, it was observed that the frequency of days when the bioclimatic comfort situation occurred in April for 16.00 hours was 5%. During May, the frequency of comfortable days was found to be 41%. It was observed that the frequency of days of comfort during June was 33.3%. It was observed that the frequency of comfortable days in July was 3.3%. There were no comfortable days during August. It has been determined that the frequency of comfortable days during the month is 3.3%. It was determined that

Table 2. Isparta city center ten-day interval- PET frequency distribution (%).

	Very Cold (<4°C)					Cold (4,1 – 8,0)					Cool (8,1 – 13,0)					Slightly Cool (13,1 – 18,0)					Comfortable (18,1 – 23,0)					Slightly Warm (23,1 – 29,0)					Warm (29,1 – 35,0)					Hot (35,1 – 41,0)					Very Hot (> 41,0)				
	10.00	12.00	14.00	16.00	18.00	10.00	12.00	14.00	16.00	18.00	10.00	12.00	14.00	16.00	18.00	10.00	12.00	14.00	16.00	18.00	10.00	12.00	14.00	16.00	18.00	10.00	12.00	14.00	16.00	18.00	10.00	12.00	14.00	16.00	18.00	10.00	12.00	14.00	16.00	18.00	10.00	12.00	14.00	16.00	18.00
Apr	0	0	10	10	10	0	0	0	10	50	20	20	10	0	10	10	20	10	50	10	10	10	30	10	20	60	20	0	10	0	0	30	20	0	0	0	0	20	10	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	20	0	20	20	20	0	40	20	10	0	0	30	60	60	30	60	10	0	10	50	20	0	0	0	0	0	0
May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	10	10	0	10	20	40	10	0	20	30	40	50	20	10	10	10	30	70	40	40	0	0	0	0	20	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	60	30	30	40	0	20	40	20	30	40	20	30	30	10	20	0	0	20	10	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	9,1	0	0	9,1	18,2	36,4	36,4	27,3	18,2	63,6	27,3	36,4	54,5	72,7	18,2	27,3	27,3	18,2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0	0	0	0	10	10	0	0	10	20	0	20	10	30	40	40	40	50	60	30	40	30	30	0	0	10	10	0	0	0	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	10	0	0	20	20	20	20	20	10	40	40	30	20	50	20	30	40	30	20	0	0	10	30	0
July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	10	20	20	20	10	60	60	40	20	30	30	0	40	60	60	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	20	10	0	0	0	0	0	0	0	0	10	20	20	0	0	20	50	20	20	10	20	30	60	20	40	10	0	0	60	30	30	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18,2	9,1	0	0	9,1	54,5	36,4	18,2	18,2	81,8	27,3	45,5	27,3	45,5	9,1	0	9,1	54,5	36,4	0
Aug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	80	40	0	0	90	20	30	70	50	10	0	30	30	50	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	30	0	0	10	60	70	40	50	70	10	0	60	50	20	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18,2	0	0	0	0	0	0	0	0	9,1	9,1	9	0	0	9,1	54,5	91	18	18	27,3	18,2	0	82	82	54,5	0
Sep	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	0	0	0	10	30	20	10	10	70	60	50	20	30	10	0	30	70	60	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0	45	0	0	0	0	55	9,1	0	0	45,5	0	45,5	18,2	0	18,2	0	36,4	63,6	45	36,4	0	9,1	18,2	55	0	0	0	0	0	0	0	0	0	0	0	0	0
	%0-10					%11-20					%21-30					%31-40					%41-50					%51-60					%61-70					%71-80					%81-90				

the frequency of days providing bioclimatic comfort conditions during October was 22.6%. While the bioclimatic comfort value is provided in the afternoon (16.00) in April, May, June, and October, it is not provided in July, August, and September.

According to the distribution of PET values measured in the evening hours (18:00) within the months of evaluation, it was observed that the frequency of the days when the bioclimatic comfort situation occurred during April was 20%. During May, the frequency of comfortable days was found to be 32.6%. During June, the frequency of the day comfort status was found to be 36.6%. It was observed that the frequency of comfortable days in July was 6.6%. There were no comfortable days during August. It was determined that the frequency of days providing bioclimatic comfort conditions during September was 36.6%. It was determined that the frequency of comfortable days in October was 6.6%. In the evening hours (18:00), bioclimatic comfort was provided only in April, May, and September, and it was observed that it was not provided in other months when measurements were made.

A table of the annual distribution of all values was created and is shown in Table 2. In this way, it was

revealed which time of day is more suitable for comfort compared to the months divided into 10-day periods.

When the graphics prepared for the research area are examined, the bioclimatic comfort status differs according to the months as well as during the days.

PET values indicate that in the city center of Isparta, the most comfortable days predominantly occur at 10.00 in October (38.3%), at 12:00 in May (28.6%), at 14:00 in May and October (28.3%), at 16.00 in May (41%), and at 18.00 predominantly between June and October (36.6%).

Şensoy et al. [62] reported that according to PET, comfort in Antalya is experienced between 10:00-12:00 in March, 09:00-17:00 in April, in the mornings and evenings in May and October, and between 10:00-17:00 in November. Despite Antalya and Isparta being neighboring cities, there are differences in the results. This could be due to geographical factors such as the Mediterranean climate in Antalya being unable to reach the city center of Isparta due to the Taurus mountains lying parallel between the two cities and differences in maritime conditions and altitude.

According to the bioclimatic variable, climatic conditions are perceived as colder in the morning and evening and warmer in the afternoon in the city center of Isparta. Türkoğlu and Çalışkan [63] obtained similar results in their study.

The results of this study indicate that there is no comfortable interval during summer, especially in August, due to high temperatures and solar radiation. These results are consistent with Çetin et al. [1], Blazejczyk [64], and Çınar et al. [43]. However, a slightly warm feature can be observed in the morning and evening in July and August, except for the hot noon hours. Matzarakis et al. [65] reported that the slightly warm range is within the thermally acceptable range [66].

Based on the monthly PET averages in this study, it is revealed that physiologically comfortable conditions exist from the end of April to the middle of June and October. Topay [46] reported that May was a comfortable month throughout the province. Mirza and Topay [67] reported that May, October, and June were comfortable months. These findings are consistent with studies conducted in the same area.

Akten [8] reported that people living in Isparta mostly preferred the afternoon for recreational activities to determine the current potential of some recreational areas in Isparta. According to the values measured in the afternoon (14:00) in this study, while bioclimatic comfort was provided in May, June, and October, comfort was not found in the other months of measurement.

Since the beginning of the 21st century, global warming has been increasing day by day. Aamir et al. [68] have informed that the increase in greenhouse gases such as CO_2 has been the leading cause of the rise in temperature over the last 50 years. Ren et al. [69] have revealed that as air temperature and solar radiation increase, humidity and wind decrease, reducing climate comfort. A similar trend is observed in the climatic conditions in Isparta. Baykal et al. [70] have predicted that in the coming years, precipitation will decrease, and drought will increase in Isparta. Sen [71] has reported an upward temperature trend during both summer and winter. It can be seen that Isparta is under the impact of global warming and has the potential to be more adversely affected in the future. This situation can intensify with unplanned urbanization and may lead to more frequent extreme weather events such as floods and storms. Natural ecosystems and human health can be affected by this situation. Therefore, it is beneficial to focus on future trends in recreational planning, along with the current conditions.

These findings show that potential recreational areas in Isparta are only comfortable during certain months and at specific hours. Providing a better climate comfort in recreational areas can encourage people to spend more time outdoors and increase their quality of life.

Conclusion

Outdoor recreation is extremely important for physical and mental health. The climatic structure significantly affects the feasibility of recreation outdoors. For this reason, determining and mapping comfortable zones and times according to accepted international indices are important data for recreation planning.

This study observes physiologically comfortable conditions from the end of April to the middle of June and October. These months are very suitable for outdoor recreational activities. Therefore, considering these months in outdoor recreation planning studies and developing plan decisions by considering the distribution of comfort throughout the day is important in determining recreational activities and suitable areas for these activities. This study is guiding decision-makers and planners.

Another factor to consider here is transportation. Previous studies show that the afternoon part of the day is preferred for recreational activities in the city of Isparta. These hours are also suitable in terms of bioclimatic comfort. Therefore, the hours allocated for outdoor recreation in the city center are relatively short. Comfort values were also found in this direction. Therefore, it will be appropriate in terms of bioclimatic comfort to consider the transportation distance in the plan decisions and to choose the areas to be reserved for recreation in areas close to the city center.

A very important relationship exists between local climatic conditions and people's physical and mental health. In this context, recreation areas in regions suitable for bioclimatic comfort will positively contribute to people's physical health. Moreover, they will contribute to reducing the costs of treatments to be applied in cases such as colds and sunstroke.

It is a detailed study of the city center of Isparta because the data used in the study reflect five different hours of each day and their frequency in ten-day periods throughout the month. A very important relationship

exists between local climatic conditions and people's physical and mental health. In this context, recreation areas to be built in regions suitable for bioclimatic comfort will contribute to the physical health of people.

In conclusion, our study offers valuable insights into bioclimatic comfort in the Isparta city center, informing outdoor recreation planning. Future work could extend this research to other cities or regions and examine climate change's impact on bioclimatic comfort. In future research, the spatial distribution and mapping of PET values could be performed using more climate stations.

Additionally, The Universal Thermal Climate Index (UTCI) might be suitable for a different study and offer a more comprehensive analysis of climate comfort. Thus, alternative indices such as the UTCI might also be explored in forthcoming studies.

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Conflict of interest

The authors declare no conflict of interest.

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