EFFECTS OF DIFFERENT RENOVATION STRATEGIES ON THE THERMAL COMFORT IN URBAN PARKS BASED ON BIOCLIMATIC DESIGN THEORY

by

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Bioclimatic design can effectively affect the environmental thermal comfort level through changing the surface of the study area. Using Zhengzhou Beach Park as a case study, the impact of three different bioclimatic design methods (changing pavement only, changing design only and changing both pavement and design) on outdoor thermal comfort, temperature, relative humidity, and wind speed under the ENVI-met model is quantitatively analysed. The results show that the three bioclimatic design schemes significantly affect the predicted mean vote of the site. The overall decrease in predicted mean vote average after pavement renovation pavement renovation is about 0.03, the overall increase in predicted mean vote average after design renovation design renovation is about 0.01, and the overall predicted mean vote average decrease after combined renovation is about 0.02. The relation among different predicted mean vote values and occupied areas under different bioclimatic design backgrounds is quantified, and the difference-value of climate index change were visualized for the first time. This study firstly uses a series of figures to show different trends of predicted mean vote and their area changes under the background of different transformation modes, which can effectively promote the refinement of the research on biological climate design.

Key words: bioclimatic design, thermal comfort, urban parks, reconstruction strategies

Introduction

The thermal environment has gradually become a key research direction that influences urban human settlement environment with the expansion of urbanisation and the intensification of global warming [1-3]. As an important component of urban space, parks can effectively regulate urban climate, creating a comfortable thermal environment for citizens [4]. Currently, the thermal comfort environment of parks has become an important factor influencing the efficiency of parks and people flow distribution [5].

Predicted mean vote (PMV) [6], physiologically equivalent temperature (PET) [7-9], and universal thermal climate index (UTCI) [10, 11] are some of the commonly used evaluating outdoor thermal comfort evaluation indexes. In addition, some climatic parameters, such as average temperature, relative humidity, solar radiation, precipitation and wind speed [12, 13], are also used for thermal comfort analysis [14, 15]. With the development of information technology, 3S technology can effectively study the relation among bioclimate and land use,

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and is also applied to the study of environmental thermal comfort [16-18]. Thermal comfort research usually relies on some professional platform, such as ENVI-met, SOLWEIG, *etc*. The ENVI-met model can use high precision data to dynamically analyze and simulate the thermal comfort of the study area, which has quickly become the most popular platform [19, 20]. The bioclimatic design is based on the results of the thermal comfort evaluation, and it changes the physical environment of the underlying surface to affect light, wind, temperature, and relative humidity of a site, thereby altering the thermal comfort level of the site. Common bioclimatic methods include replacing ground paving materials, changing vegetation planting methods and area, and adjusting the water area [21, 22]. The specific analysis results are:

- By replacing ground paving materials with high solar reflectance and high infrared emissivity, the absorption of solar radiation can be reduced, limiting temperature rise and easing the city's hot climate [23, 24]. The method of replacing the site's paving materials does not change the original land use nature of the site, and it is also simpler and easier to implement in park reconstruction.
- Plant evapotranspiration reduces air temperature while increasing relative humidity [25]. Therefore, changing the vegetation pattern and area can also affect the thermal comfort of the environment [26].
- The size of the water body directly affects the relative humidity and wind speed of the site, changes the heat radiation of the underlying surface, and forms a cold island effect in an urban park with plants, reducing the thermal comfort of parks [27, 28].

Bioclimatic design can effectively improve the thermal comfort level of the environment, and is widely used in environmental analysis and transformation research [29, 30]. For example, *comfa* method and *TS-Givoni* method are used to evaluate the thermal comfort of the conventional situation and the study area after the bioclimate design. These two methods clearly show that the thermal comfort of the study area has been greatly improved after the bioclimate design [21]. Karakounos *et al.* [31] analyze how bioclimatic design affects outdoor thermal comfort, and they found increase of vegetated areas and the creation of water surfaces are more suitable than the application of cool paving materials in some scenes. Adiguzel *et al.* [32] provide reference for urban planning from the perspective of environmental thermal comfort. Based on the previous studies on the external environment of buildings, there are mounts of bioclimatic design studies in the large-scale space, however, still exists a lack of detailed research on specific indicators in small-scale space.

Taking Zhengzhou Beach Park as the study area, with the support of the ENVI-met model, the difference-value of thermal comfort index PMV and climate parameters such as temperature and relative humidity under three different strategies (changing pavement only, changing design only and changing both pavement and design) was simulated and visualized. The research is helpful for revealing the relation between thermal comfort index and corresponding area changes, which can provide theoretical or case-based guidance for the Bioclimatic design in small-scale parks.

Materials and methods

Study area

With a total area is 1.98 ha, the Longzihu Beach Park in Jinshui District, Zhengzhou City, Henan Province, China was selected as the research area, fig. 1. The study area belongs to the temperate continental monsoon climate zone, with the four seasons distinct. The average annual temperature is 14.4 °C. August is the hottest month with an average temperature of 27 °C.

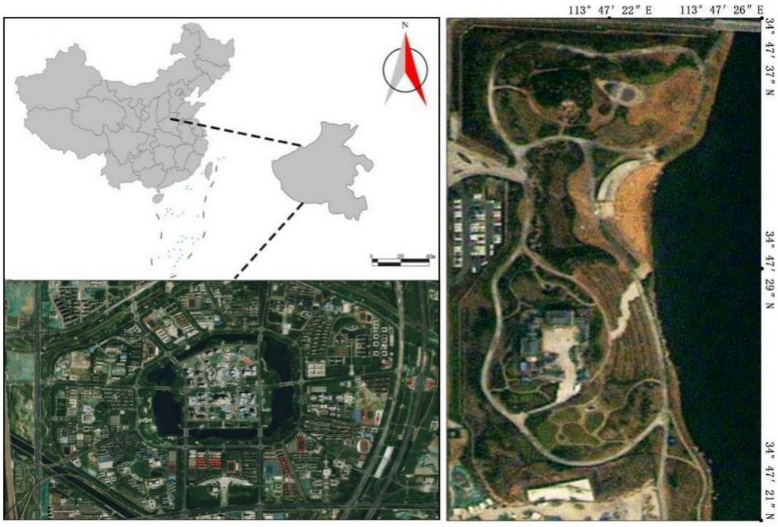

Figure 1. Location analysis map of the study area

The Beach Park is located in the southeast area of Longzi Lake Park. The park is mainly composed of vegetation, pavement, water, and few buildings. The plant species in the park are rich, forming a multi-type plant community. The park road is asphalt pavement, and the squares are mainly paved with granite. The specific land use status is shown in tab. 1.

Table 1. Proportion of different land use

Land use type	Tree	Shrub	High density grassland	Low density grassland	Hard pavement	Water area	Sandy beach	Architecture
Proportion, *n*	22.07%	10.80%	4.92%	25.01%	17.30%	14.25%	2.20%	3.45%

Note: The data in Table 1 is obtained from land classification and area statistics of remote sensing image in study area.
The remote sensing image can be downloaded from http://www.gscloud.cn.

Data source and processing

Summers in the study area are long and hot, which has a significant impact on the outdoor thermal environment. June 4 is selected for its highest temperature which also provides the worst thermal experience in the month. With a 09:00 a. m. starting time, a simulation duration of 11 hours, and output data recorded every 1 hour. According to full-day monitoring point temperature detection results, 14:00 p. m. is the highest time of the day for site temperature. Therefore, this period was selected for thermal comfort simulation. Other climate data (initial temperature, relative humidity*, etc.*) were derived from the measured data of China Meteorological Administration. The geospatial data was based on raster data, which can be downloaded for free at http://www.gscloud.cn/, and processed with the GIS10.0 platform(GIS is an important platform for collecting, storing, managing, calculating, analyzing, displaying and describing geospatial data). The simulation grid accuracy of the ENVI-met was 4 m × 4 m × 2m (ENVI-met is a 3-D urban climate modelling tool that simulates the microclimatic effects of buildings, vegetation, and other objects. It can be used for urban planning, green infrastructure, and climate change related decision-making). The data sources are shown in tab. 2.

Table 2. Basic parameter setting of simulation test

Type	Project	Parameter
Site model	Grid number	50 × 25 × 30
	Grid accuracy	4 m × 4 m × 2 m
	Grid soil definition	Defaults
	Geographic co-ordinates	N 34.73°, E 113.71°
	Simulation time	09:00 a. m. to 20:00 p. m.
Environmetal parameter	Air temperature	Maximum air temperature 39.6 °C Minimum air temperature 21.7 °C
	Relative humidity	Maximum relative humidity 60% Minimum relative humidity 12%
	10 m wind speed	3.9 m/s
	Wind direction	137°

Methods

Methodological framework

Firstly, the thermal comfort evaluation of the current situation of the study area is carried out, and three different bioclimatic design strategies are proposed according to the evaluation results. Then, the thermal comfort simulation results of the three strategies are contrasted to the current situation, and the impact of different strategies methods on the thermal comfort indexes are clarified. With the support of GIS10.0 and Envi-met model (https://www.envi-met.com/), the research results are visualized. The methodological framework was shown below, fig. 2.

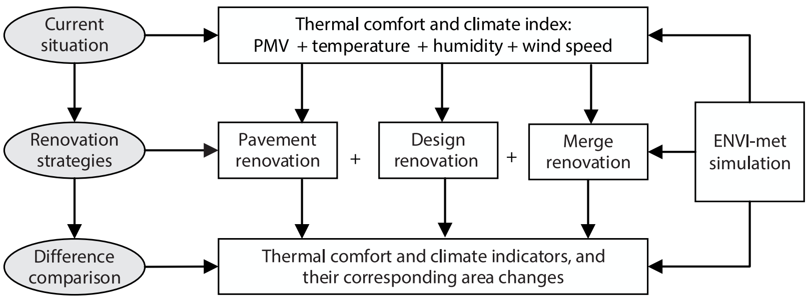

Figure 2. Methodological framework

Thermal comfort evaluation

The PMV was selected as the thermal comfort evaluation index and temperature, relative humidity, and wind speed as the pedestrian height of the site as the environmental index A comparative analysis of the status quo and the period after the renovation was carried out on the Envi-met model [33].

The PMV is the predict mean votes, which represents the hot or cold feelings of most people in the same environment [34]. The PMV level ranged from −4 (very cold) to 4 (very hot), with 0 being the comfort value. Based on previous studies [35-37], the ideal interval of PMV can be identified by the local situation. Therefore, the ideal interval of PMV is identified from –1 to 2.

Interpretation of the result

Site status simulation

The current site data in section *Data source and processing* was entered into the ENVI-met drawing, as shown in fig. 3.

As shown in fig. 3, the PMV of area of study was between 1.65 and 2.46 at 14:00 p. m. When combined with the actual site, the PMV value between 1.00 and 2.00 was mainly distributed near the park's buildings, on the water surface, and in the shades of trees, indicating that people generally feel comfortable in these areas. The PMV values exceeding 2.00, which belong to the thermal level, were found in 45.90% of the study areas, primarily around the northwest entrance of the park, some park roadways, and large paved squares. These areas are constructed with asphalt and low reflective square bricks. The temperature ranges from 31.80~35.04 °C, with a decreasing trend from west to east from the east square to the central greenery to the water surface in the west. Relative humidity levels vary from 29.70-39.20%, indicating an opposite trend to temperature. The areas with lower relative humidity in the park are mostly found in the paved square away from the water. The wind speed on the water surface in the eastern part of the study area is the highest, followed by sandy beaches and areas with less vegetation, with a wind speed difference of 2.50 m/s. Wind speeds around buildings and in areas with dense plant communities are significantly low.

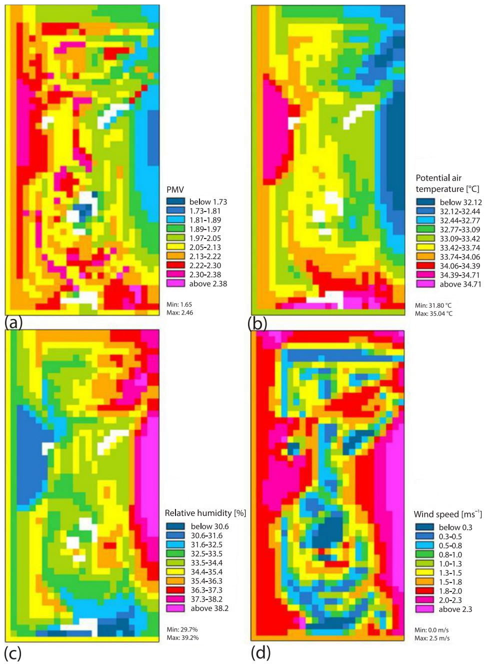

Figure 3. Site status simulation; (a) PMV, (b) air temperature, (c) relative humidity, and (d) wind speed

Bioclimatic renovation design plan

According to the thermal comfort evaluation, the pavement renovation (Case A), design renovation (Case B), and combined renovation (Case C) simulation were carried out for the study area, respectively, fig. 4. The renovation plan mainly carries out bioclimatic design for areas with low comfort level, and minimizes manual intervention as much as possible on the original site.

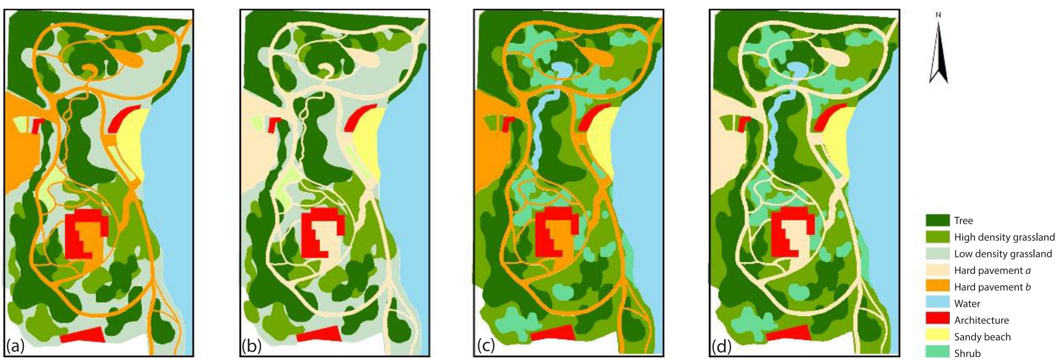

Figure 4. (a) Current state, (b) Case A, (c) Case B, and (d) Case C

Case A. Cool materials were used to replace conventional paving materials at the entrance and park roads in the north-western part of the park, tab. 3.

Table 3. Thermal and optical properties of the materials [38, 39]

	Material name	Solar reflectivity coefficient	Emittance coefficient	Heat conductivity [$Wm^{-1}K^{-1}$]
Conventional materials	Asphalt	0.10	0.85-0.93 (0.89)	0.669
Cool material	Photocatalytic concrete based mortar	0.37	0.89	1.28
	Pavement tiles	0.68	0.92	1.99

Case B. Replace low density grassland with high density grassland in the park, increase vegetation on the bare ground and add water at the entrance of the park. The specific land use indicators after Case B are shown in tab. 4.

Table 4. Proportion of land use area after renovation

Land use type	Tree	Shrub	High density grassland	Low density grassland	Hard pavement	Water area	Sandy beach	Architecture
Proportion	25.32%	12.43%	25.05%	0%	15.80%	15.75%	2.20%	3.45%

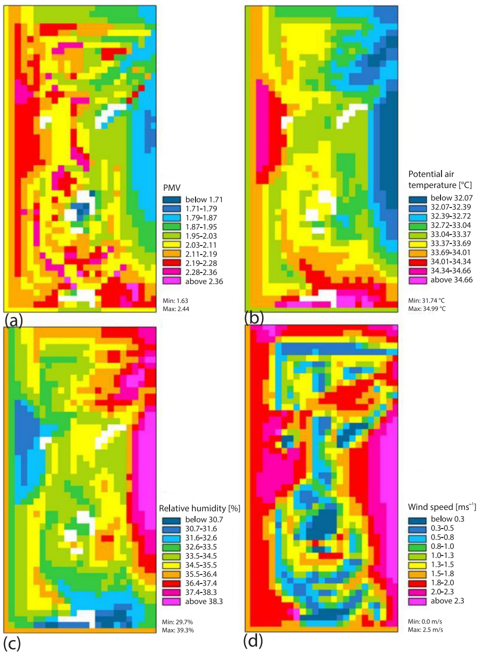

Figure 5. Case A simulation; (a) PMV, (b) air temperature, (c) relative humidity, and (d) wind speed

Case C. The combined renovation is the integration of Case A and Case B.

Influence of Case A on thermal comfort

The site data of the paving renovation plan was entered into the ENVI-met for simulation, as shown in fig. 5.

As shown in fig. 4, the average PMV range is 1.63-2.44. The maximum temperature difference at pedestrian height in the study area is 3.25 °C, with high temperature areas mainly located in the northwest and south. The two parts are also high humidity areas in the park. The relative humidity in the park is 34.50%, with a maximum relative humidity difference of 9.60%. The wind speed on the eastern water surface in the study area is the highest, reaching 2.50 m/s.

The D-value graph between Case A and current situation

The evaluation results of the Case A and the current situation of the site were spatially superimposed to obtain a difference map between them. The red area represents the area where the index rises after the renovation, while the blue area represents the area where the index drops after the renovation, as shown in fig. 6.

As shown in fig. 6, the overall PMV was reduced after pavement renovation, with a reduced value of about 0.04. The road and entrance into the northwest park were significantly lowered. The comfort level of the water on the east side and the dense forest area in the centre of the park remained relatively unchanged.

The overall temperature in the study area was reduced, with a maximum reduction of 0.33 °C. According to statistics, the area in the study area where the temperature dropped by 0.20 °C or more accounted for 12.50% of the total area at 14:00 hours, while the relative humidity in the park increased slightly, with a maximum increase of 1.30%. There was almost no change in wind speed.

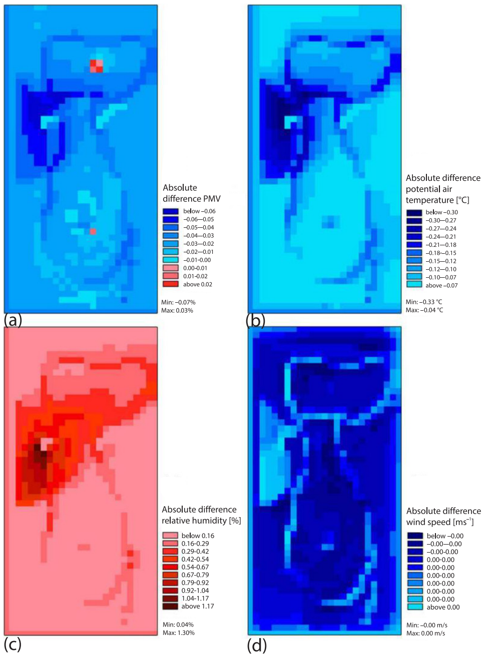

Figure 6. Analysis of the difference between the Case A and the current situation of the site; (a) PMV, (b) air temperature, (c) relative humidity, and (d) wind speed

Change area and change interval of thermal comfort and related climatic indicators of the site after Case A

As shown in fig. 7, the area occupied by different PMV values decreases on both sides and increases in the centre after using highly reflective materials to replace traditional paving materials. The area of the site with a PMV value of

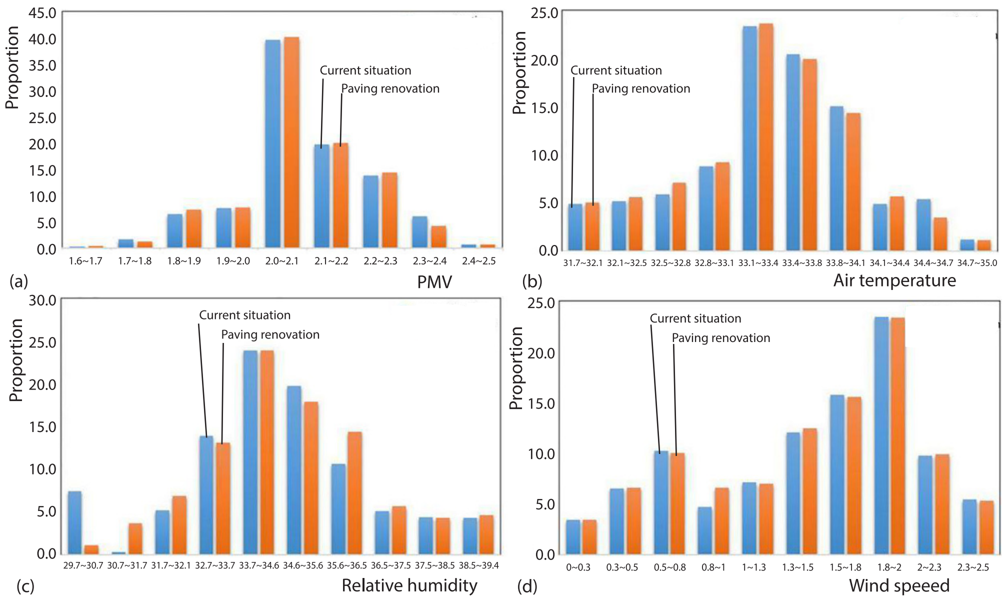

Figure 7. Analysis of the change area and change interval of thermal comfort and related climatic indicators of the site after Case A; (a) PMV, (b) air temperature, (c) relative humidity, and (d) wind speed

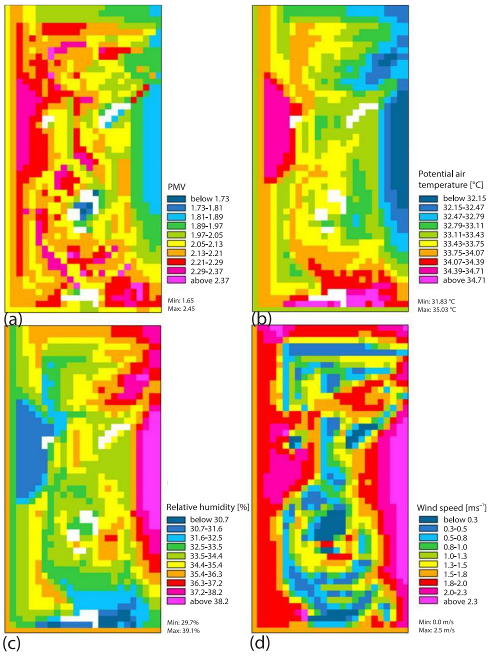

Figure 8. Case B simulation; (a) PMV, (b) air temperature, (c) relative humidity, and (d) wind speed

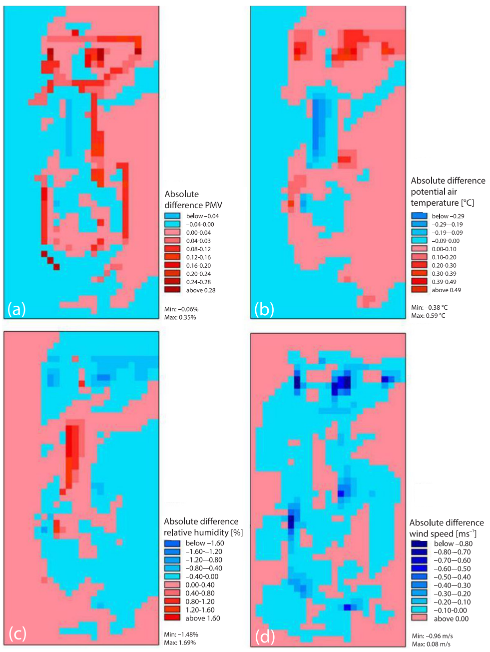

Figure 9. Analysis of the difference between the Case B and the current situation of the site; (a) PMV, (b) air temperature, (c) relative humidity, and (d) wind speed

1.60-1.80 was reduced from 1.90-1.50%. When the PMV value was between 1.80 and 2.30, the proportion of the pavement after renovation relative to the current proportion increased from 87.10-89.60%, which is comfortable. The area of the site with PMV values ranging from 2.30-2.50 was reduced from 6.60-4.80%, and the comfort level was improved as a result. When the temperature was between 31.70 °C and 33.40 °C, the proportion of Case A was higher than the current proportion, and the proportion of the low temperature area increased. When the temperature was between 33.40 °C and 35.00 °C, the proportion of Case A increased. The proportion of the high temperature area decreased. After pavement renovation, the lowest relative humidity range was 29.70-30.70%, the proportion of the area was significantly reduced, and the proportion of 30.70-32.10% and 35.60-39.40% was obvious increased. According to the overall proportion, the change in wind speed was insignificant, and the biggest change was in the range of 0.80-1.00, which is consistent with the actual situation.

Influence of Case B on thermal comfort

The site data for the Case B was entered into the ENVI-met for simulation, as shown in fig. 8.

The maximum temperature difference of pedestrian height in the study area is 3.20 °C, with high temperature areas are mainly located in the northwest and south. These two parts of the park have high relative humidity. The relative humidity in the park is 34.40%, with a maximum relative humidity difference of 9.40%. The wind speed on the eastern water surface of the study area is the highest, reaching 2.50 m/s. According to statistics, the average value of PMV ranges from 1.65-2.45.

The D-value graph between Case B and current situation

The evaluation results of the Case B and the current situation of the site were spatially superimposed, and the difference map between them was obtained, as shown in fig. 9.

As shown in fig. 9, the PMV value in the study area was generally reduced after the Case B. The PMV value decreased in 51.20% of the area, whereas it increased slightly around the water bodies and some roads, which account for 9.80% of the total area.

The temperature in most of the study area was significantly reduced. According to statistics, the area where the temperature of the program decreased after the implementation of the bioclimatic intervention measures accounted for 47.20% of the total area. The area where the temperature decreased the most was the newly added water area, with a maximum decrease of about 0.40 °C and a slight temperature increase in 7.20% of the area. The maximum increase in temperature was about 0.60 °C. According to the relative humidity difference table, the area where the relative humidity increased or remained unchanged accounted for 52.20% of the total area, and the area with a large increase is similarly centred around the newly added water area. The area where the wind speed decreases accounted for 54.60% of the total area, with a maximum decrease of about 1.00 m/s and a slight increase.

Thermal comfort indexes and change area after Case B

As shown in fig. 10, the area ratio of the PMV value shows a wave-shaped change after Case B . The area of the site with a PMV value of 1.60~1.90 was reduced from 8.30-6.00%. When the PMV value was between 1.90 and 2.10, the overall comfort was improved, and the proportion of areas with PMV < 2.00 increased from 7.60-8.10%. The proportion of the area with PMV > 2.00 dropped from 39.60-34.80%. When the PMV value was between 2.10 and 2.50, the proportion of Case B increased from 40.10-47.40%, and the comfort level decreased. In the area between 32.50-33.40 °C, the proportion after Case B increased. Overall, the area occupied by different temperatures varies unevenly. The overall relative humidity of the site was reduced. The change in wind speed was insignificant, and decreased locally, mainly in the 0.30-0.50 range.

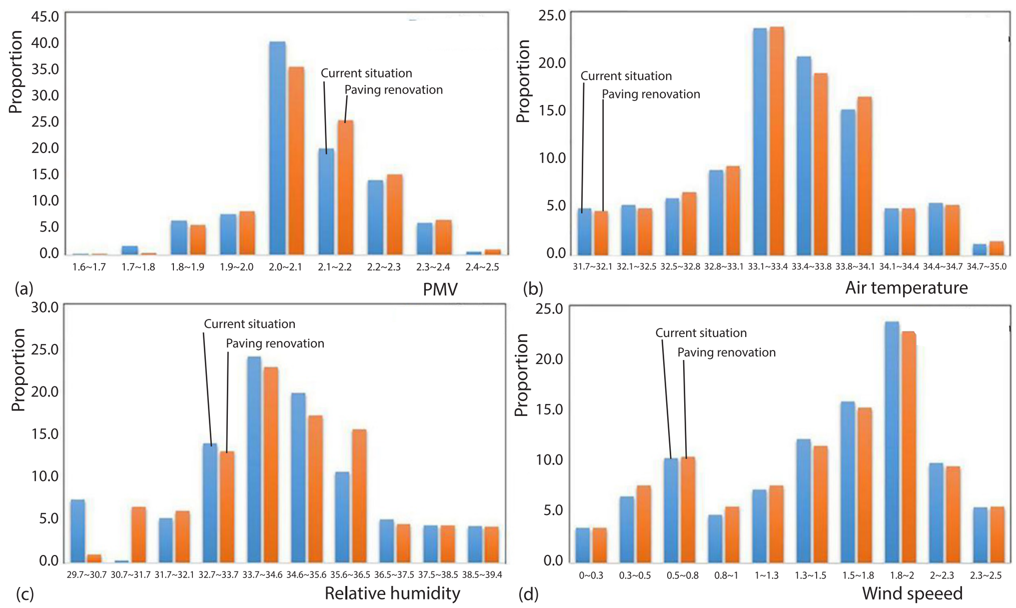

Figure 10. Comparison of proportions between Case B and current situation; (a) PMV, (b) air temperature, (c) relative humidity, and (d) wind speed

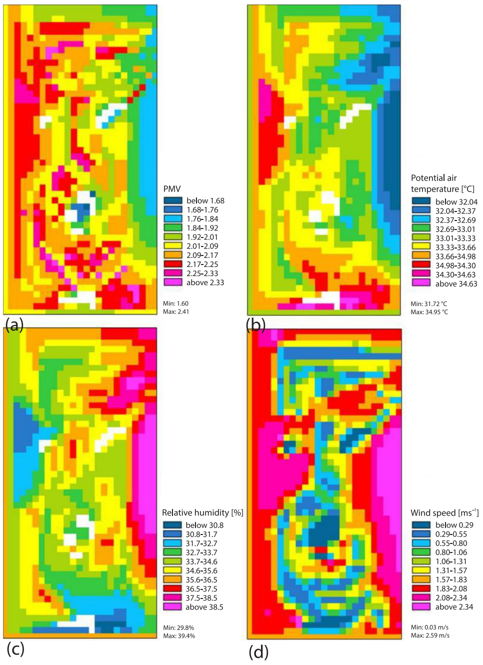

Figure 11. Case C simulation; (a) PMV, (b) air temperature, (c) relative humidity, and (d) wind speed

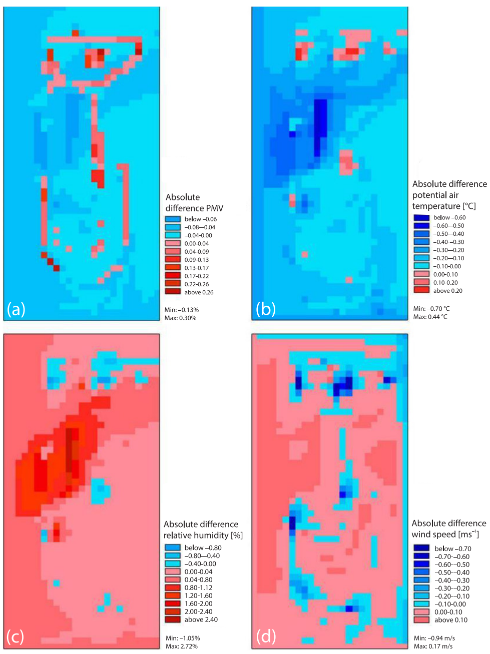

Figure 12. Analysis of the difference between the Case C and the current site; (a) PMV, (b) air temperature, (c) relative humidity, and (d) wind speed

Effect of changing Case C on thermal comfort

The site data of the Case C plan was entered into the ENVI-met for simulation, as shown in fig. 11.

Statistics show that the average PMV range is 1.60-2.41, and the maximum temperature difference of pedestrian height in the study area is 3.20 °C. The maximum temperature is lower than the results after implementing the bioclimatic design plan. The relative humidity in the park is 34.60%, with a maximum relative humidity difference of 9.60%. The wind speed on the eastern water surface of the study area is the highest, reaching 2.59 m/s.

The D-value graph of comfort between Case C and current situation

The evaluation results of the Case C and the current situation of the site were spatially superimposed, and the difference map between them was obtained, as shown in fig. 12.

As shown in fig. 12, the overall PMV value was reduced after the Case C, with the reduced area accounting for 90.2%. The PMV value near the water bodies and some roadways was slightly increased, accounting for 9.80% of the total area. Bioclimatic intervention measures, such as increasing water area and increasing vegetation area, can positively influence thermal comfort.

According to microclimate analysis, the overall temperature in the study area was significantly reduced after the Case C. The place where the temperature dropped the most was the newly-added water area, with a maximum decrease of 0.70 °C, a slight increase in temperature of 1.3% of the area, and a maximum increase of 0.44 °C. According to the relative humidity difference table, the area with increased relative humidity accounts for 89.00% of the total area, with a maximum increase of 2.70%, which is also centred around the newly added water bodies. The wind speed increased slightly on the eastern water surface, western open areas, and low plant areas in the garden, accounting for 38.20% of the total area, with a maximum value of 0.17 m/s. In densely planted areas, the maximum value was 0.94 m/s.

Thermal comfort indexes and change area after Case C

As shown in fig. 13, the area occupied by different PMV values decreases on both sides and increases in the centre. The area of the site with a PMV value of 1.60~2.10 was reduced from 55.50-48.00%. When the PMV value was between 2.10~2.30, the proportion of the Case C increased from 33.50-42.50%, relative to the current proportion, which is comfortable. The area of the site where the PMV value is 2.30~2.50 decreased from 7.50-5.60%, and the comfort level was improved. The proportion of temperature in the range below 33.40 °C showed an upward trend after the merger and renovation, and the relatively low temperature area increased. The temperature proportion of the temperature range above 33.40 °C showed a downward trend after the merger and renovation, and the relatively high temperature area decreased. The overall relative humidity increased, with the wind speed unevenly changed.

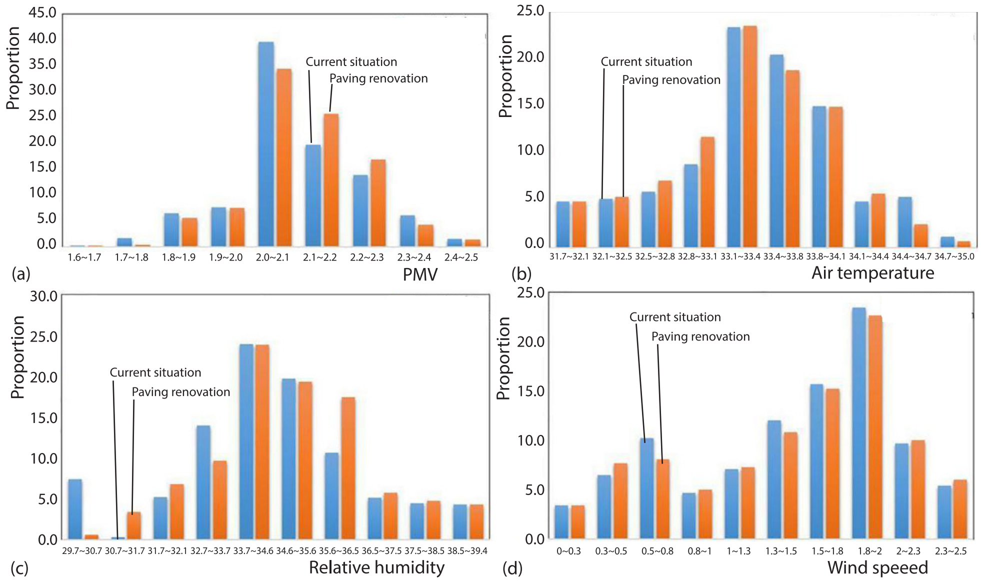

Figure 13. Analysis of the difference between the Case C and the current situation of the site; (a) PMV, (b) air temperature, (c) relative humidity, and (d) wind speed

Discussion

– The comparative study of different renovation strategies

Under the influence of global changes, the renovation of thermal environment has gradually attracted the attention of a large number of scholars [40]. Fintikakis *et al.* [41] calculation of bioclimatic index shows that bioclimatic design can improve thermal comfort. Xu and Wang [42] put forward a set of ecological strategies and methods of urban design to adapt to hot and humid areas based on bioclimatic conditions. Dong *et al.* [43] tried to establish the framework of bioclimatic design methods outdoors. However, in most studies, only the comparative study before and after the different renovations was carried, respectively, lacking the overlay impact of multi-strategy renovation. Different impact of strategies (changing pavement only, changing design only and changing both pavement and design) on thermal comfort indexes were calculated and contrasted. Results show that the overlay impact of multi-strategies on thermal comfort is not the sum of each one.

– The visualization of difference-value of climate indexes

Relevant scholars also compared the changes of thermal comfort indexes before and after the renovation, with D-value of thermal comfort indexes mapped. For example, Sun *et al.* [44] mapped the D-value of PET in a park in Beijing, Lao *et al.* [6] mapped the D-value of PMV at street scale. However, this paper mapped the D-value of climate indexes (air temperature, relative humidity, and wind speed) to reveal the factors affecting thermal comfort difference more accurately.

– Area changes of different climate indexes related to thermal comfort

Karakounos *et al*. [31] quantified the impact of different bioclimatic schemes on thermal comfort, and mapped the simulation results. Lao *et al*. [6] measured the effects of buildings and greening facilities on outdoor temperature, wind speed and thermal comfort in summer by the simulation of real scene and non-vegetation scene in typical blocks of Zhongshan City. Most researches concentrate on the impact of different renovation strategies on thermal comfort at a macro scale, while, this paper quantified and mapped the area changes of different climate indexes in different renovation strategies (figs. 7, 10, and 13), which is helpful to promote the thermal comfort research in a finer scale.

– Limitations of this study

There still exist limitations. The trees and grassland are simplified in the scene, which is an approximation of the real structure and lead to a slight error. The model can be refined for more accurate results in the future research.

Conclusions

After comparing the thermal comfort and microclimate of the site after bioclimatic design to the original site, the following conclusions were reached.

- *The three bioclimatic design schemes have an impact on PMV, and their effects are obvious.* The PMV, temperature, and relative humidity all changed in a large area after the pavement renovation: PMV range decreased from 1.65~2.46 to 1.63~2.44, with the area where the PMV value decreased by more than 0.04 accounting for 16.00%, a maximum temperature decrease of 0.33 ℃, and a maximum relative humidity increase of 1.30%. After the design, the area where the PMV value decreased accounted for 51.20%, with a maximum decrease of 0.06, the area where the temperature decreased accounted for 46.50%, with a maximum temperature decrease of 0.38 ℃, the area where the relative humidity increased accounted for 10.20%, with a maximum increase of about 1.70%, and the area where the wind speed decreased accounted for 54.60%, with a maximum decrease of about 1.00 m/s.
- *The two renovation methods produce various PMV changes, and the area changes of different PMV intervals show different trends.* The proportion of PMV value in the area shows a decreasing and increasing trend on both sides after the pavement renovation. The area of the site with a PMV value of 1.60~1.80 was reduced from 1.90-1.50%. When the PMV value was between 1.80 and 2.30, the proportion of the pavement after renovation relative to the current proportion increased from 87.10-89.60%, and the comfort level was reduced. The area of the site with a PMV value of 2.30-2.50 decreased from 6.60-4.80%. After the design renovation, the proportion of PMV value in the area showed a wave-shaped change. The area of the site with a PMV value of 1.60~1.90 was reduced from 8.30-6.00%. When the PMV value was between 1.90 and 2.10, the overall comfort was improved, and the proportion of areas with PMV < 2.00 increased from 7.60-8.10%, while the proportion of areas with PMV > 2.00 decreased from 39.60-34.80%. When the PMV value was between 2.10 and 2.50, the proportion of design renovation increased from 40.10-47.40%.

- *Although the PMV result is similar to the superposition of two bioclimatic designs after the combined renovation, the corresponding area changes of local PMV were significantly different*. Overall results: the overall decrease in PMV average after pavement renovation is about 0.03, the overall increase in PMV average after design renovation is about 0.01, and the overall PMV average decrease after combined renovation is about 0.02. Partial result: if the pavement is changed, the area of the site with a PMV value of 1.60-1.80 will be reduced from 1.90-1.50%, and the area of the site with a PMV value of 2.30-2.50 will be reduced from 6.60-4.80%. If the design is changed, the PMV value will be 1.60. The site area of ~1.80 was reduced from 1.90-0.50%, and the proportion of the area with a PMV value of 2.30 and 2.50 increased from 6.60-7.50%. After the combined renovation, the area of the site with PMV value between 1.60 and 1.80 was reduced from 1.90-0.70%, and the proportion of the area with a PMV value of 2.30-2.50 reduced from 6.60-5.60%.

Authors' contributions

Conceptualization, Fan Q. and Zhang H.; methodology, Fan Q.; software, Zhang H.; validation, Fan Q., Zhang H. and Zhang C.; formal analysis, Fan Q.; investigation, Zhang H.; resources, Fan Q. and Zhang C.; data curation, Zhang H.; writing-original draft preparation, Zhang H.; visualization, Fan Q.; supervision, Fan Q. and Zhang C.; funding acquisition, Fan Q. All authors have read and agreed to the published version of the manuscript.

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