Assessment of the bioclimatic comfort in different outdoor public spaces of Lisbon

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1. INTRODUCTION

Outdoor public spaces in urban areas promote the social interactions and provide the opportunity to perform recreational activities (Thorsson et al., 2004), thus improving the quality of life in cities.
The characteristics of these spaces influence their usage; among them, the microclimatic conditions play an important role, since they affect the thermal and mechanical comfort of users (Nikolopoulou et al., 2001; Givoni et al., 2003). The assessment of outdoors bioclimatic comfort is a difficult task, due to the high variability of the outdoor environment and the role of subjective factors (especially psychological and cultural) in the perception of the thermal environment (Höppe, 2002, Knez and Thorsson, 2006; Oliveira and Andrade, 2007). Today, it is well known that models developed to assess indoor conditions, based on the human body thermal balance (Fanger, 1972; Gagge et al., 1986; Parsons, 1993) are not enough to understand outdoor thermal comfort, and they can be used as an approach only to know the thermophysiological component of the thermal comfort. The assessment of the bioclimatic comfort in outdoor spaces requires the inclusion of other factors, specifically personal (such as age and clothing insulation) and subjective parameters (individual preferences and cultural aspects) (Stathopoulos et al., 2004; Knes and Thorsson, 2006).

The city of Lisbon has a wide range of outdoor public spaces, such as parks, squares, green areas and riverside walks, each with different characteristics and usage. The Mediterranean climate of the city promotes outdoor activities, especially during spring and summertime, but in winter, when the meteorological conditions are favourable, it is also possible to find people in these places.
For this study, integrated in the UrbKlim Project[2] two riverside leisure areas of the city of Lisbon, with different characteristics (fig. 1), were selected, in order to:
i) Assess the relationships between the different parameters that can influence human comfort in urban outdoor spaces, particularly in riverside areas;
ii) Analyse the perception of bioclimatic comfort by users of outdoor public spaces, in relation to their personal characteristics and the meteorological conditions.

2. METHODS

Field data was collected in both places, in every season, during the years 2006 and 2007. The field work included weather measurements, questionnaires and a photographic survey. Measurements of air temperature (Ta), wind speed (v) and relative humidity (RH) were made every 30 seconds, simultaneous with the interviews (in average, 3 measurements were made during each interview). Solar (K) and infrared radiation (L) were measured nearly every 30 minutes. To assess the changes in the thermal environment during the field surveys, a Tiny Tag 433-7841 termo-hygrometer (Gemini Data-Loggers) was placed on a lamp post at a height of 2 meters, facing north an sheltered from solar radiation, recording Ta and RH every 10 minutes. As explained in Oliveira and Andrade (2007), Physiological Equivalent Temperature (PET: Höppe 1999; Matzarakis et al. 1999) was used as a way to evaluate the combined influence of all the meteorological parameters, assuming constant values of clothing and physical activity.

A simple and concise questionnaire was applied to people passing by on the sidewalk, sitting or standing in the area, engaged in a low to moderate physical activity and over 16 years old. It was divided in two parts: the first one comprised the personal characteristics of the people and their use of the space, such as age, clothing, company, reasons to be in the area, among others. The second part comprised the perception of the interviewees in relation to the atmospheric conditions, with four different questions (fig.2):

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- question 19 (Q19) was about the sensation of the interviewees about each of the meteorological parameters (temperature, humidity, solar radiation and wind); answers to that question (Thermal Sensation Votes - TSV, when speaking about temperature and Wind Sensation Votes – WSV, about wind speed) were classified in a 5 point scale;
- in question 20 (Q20) it was asked which was the most unpleasant weather parameter;
- question 21 (Q21) was about the general state of comfort;
- in question 22 (Q22) it was asked how the interviewees would like to change any of the individual parameters in order to improve their satisfaction; that corresponds to Thermal Preference Votes (TPV to air temperature) or Wind Preference Votes (WPV) .

The analysis was carried out based on the answers concerning the desire to decrease, maintain or increase the values of each weather parameter (air temperature, wind speed, relative humidity and solar and long wave radiation). Multiple logistic regression (Vitinghoff et al., 2004) was used to analyse the quantitative relation between preference votes and environmental and personal parameters. In this analysis, each of the three categories of TPV was considered as a different dependent variable: (i) preference to decrease (DECR), (ii) to maintain (MAINT) and (iii) to increase values (INCR).
In relation to the analysis of TPV, the proportion of people that give different answers in relation to the atmospheric conditions was calculated. TPV was considered as a dependent categorical variable, and atmospheric and personal conditions as independent variables, which variation can also lead to a change in the answers.

3. RESULTS

Nearly 1000 questionnaires were made, considering both places and all the seasons. Women represented 53 % of the sample. The most frequent age group found was 25-34 years old, with interviewees being younger in PN than in ALC. Almost all of the people inquired were in the study areas for leisure purposes. 24% of the inquired persons were seated, 75% were standing and from these, a large majority was walking slowly. Estimated Clo values varied between 0.24 and 1.75 (average 0.69). In summer, average Clo value was 0.4, in winter was 1.3, in autumn was 0.57 and in spring was 0.67. There were no significant differences in Clo values in relation to gender; on the contrary, age is an important factor and it was possible to observe an increase in the average clo values in the older group ages. A high level of satisfaction with thermal and wind conditions was found: 88 % of interviewees were satisfied with these two parameters.

In relation to TPV, 11% of the interviewees declared to prefer a lower Ta and 21% a higher one. A large percentage of people that considered Ta hot (43%) expressed the preference to maintain the values of this variable, particularly in spring and autumn. For the people that considered Ta very hot or cool, the majority declared to prefer a change in Ta values. Considering the relation between TPV and Ta, it was found a “central zone” of maximum comfort situated between 22ºC and 28ºC; within this range, 80% of people declared to be satisfied with Ta; when Ta goes down below 15ºC the proportion of TPV INCR surpassed 75%. With Ta above 32ºC, over 50% of the people voted DECR (fig.3). TPV INCR increased when Ta and age decreased (TPV INCR were given by 25% of people aged less than 35 years old, but only by 15% of those over 54 years old) and rose when wind (Vx) increased. RH influences also significantly the TPV DECR (naturally increasing the wish to lower temperature when RH increases).

When considering wind, it must be considered that the perception of wind depends not only of the speed but also of turbulence (Vx = speed + turbulence) (Oliveira and Andrade, 2007). V was classified as the most unpleasant variable by 21% of people. There were differences between gender, since 70% of men answered MAINT against 61% of women. The difference was only evident with Vx above 1.4 ms^{-1} and was particularly strong above 3.1 ms^{-1}: 61% for men, 42% for women (fig. 4). The general sensitivity to wind decreased with age: the percentage of WPV DECR was maximum in the age group 25-34 years old and minimum above 55 years old.

4. DISCUSSION

The range of acceptability of outdoor conditions is very wide referring to the studied areas and activities. The acceptability of warmer conditions is higher than of cooler conditions and adaptive strategies are undertaken by people (like change in clothing and moving between shade and full sunshine) to improve their level of comfort outdoors.

The preference for a different temperature depends largely on the season and is strongly associated with wind speed (and, in a smaller level, in the “hot side”, by RH). Answers about Ta corresponded, in fact, to the perception of the overall thermal conditions. Age was the only personal factor significantly related with thermal preference, with a general decrease of discomfort with increasing age (mainly in the older classes – above 54 years old), possibly due to higher clothing insulation and lower climatic sensitivity of older people (Parsons, 1993; Frank et al., 2000). It seems that the meaning of “hot Ta” is not the same in summer and in the transitional seasons. A similar high acceptance of hot conditions in a transitional situation was described in Höppe (2002); de Freitas (1985) also described, in hot conditions and in a leisure context, a similar difference between thermal sensation and thermal preference.
Most people declared preference for lower wind speed in all seasons. The perception of wind shows significant differences depending on gender, with women declaring a lower level of comfort with higher wind speed. Clothing does not seem to account for these differences, since the Clo values do not differ significantly between genders; they can be due to physiological differences, and to preferences and cultural characteristics (Mäkinen et al., 2006).

5. CONCLUSION

These findings show that besides atmospheric conditions personal parameters and subjective factors can influence the perception of bioclimatic comfort in outdoor open spaces, and that all these different kind of parameters can be included in a model. Age,associated with clothing, influences thermal preference and the level of comfort. Gender influences the level of satisfaction with wind speed and variability. These results can contribute to the design of more satisfying leisure areas in cities.

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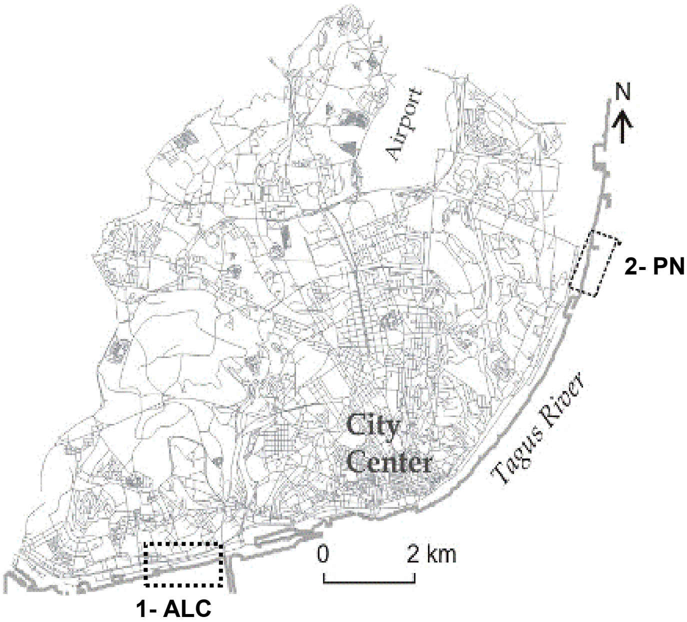
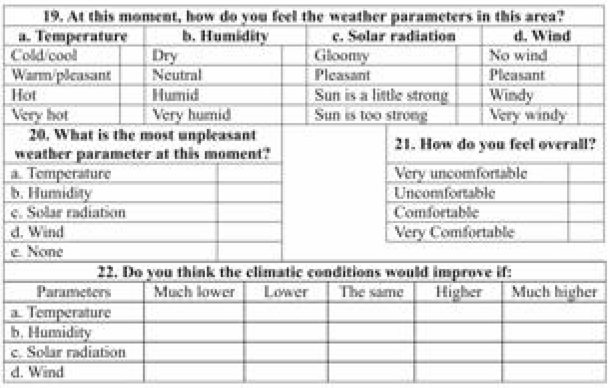


Fig.1. Location of the studied riverside areas



19. At this moment, how do you feel the weather parameters in this area?							
a. Temperature		b. Humidity		c. Solar radiation		d. Wind	
Cold/cool		Dry		Gloomy		No wind	
Warm/pleasant		Neutral		Pleasant		Pleasant	
Hot		Humid		Sun is a little strong		Windy	
Very hot		Very humid		Sun is too strong		Very windy	

20. What is the most unpleasant weather parameter at this moment?	
a. Temperature	
b. Humidity	
c. Solar radiation	
d. Wind	
e. None	

21. How do you feel overall?	
Very uncomfortable	
Uncomfortable	
Comfortable	
Very Comfortable	

22. Do you think the climatic conditions would improve if:					
Parameters	Much lower	Lower	The same	Higher	Much higher
a. Temperature					
b. Humidity					
c. Solar radiation					
d. Wind					

Fig. 2. The questions related to the perception of comfort and atmospheric conditions

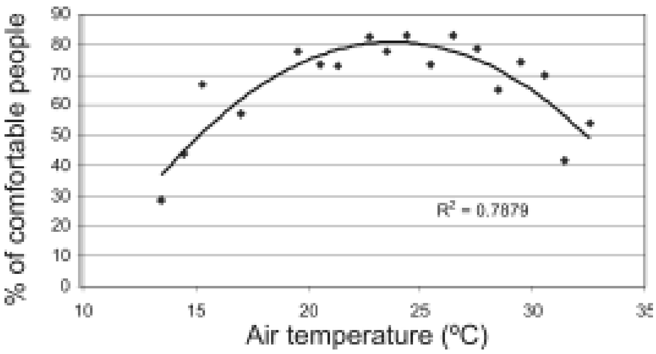


Fig. 3. Thermal Preference Votes versus air temperature

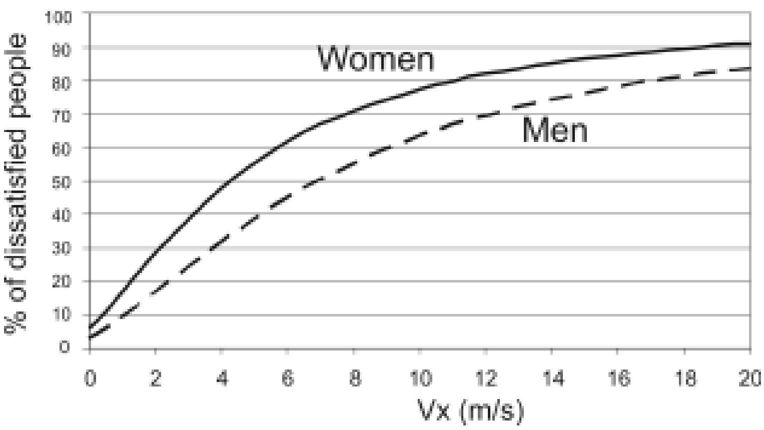


Fig. 4. Level of satisfaction with wind in relation to gender (modelled with multiple logistic regression)