RESEARCH ARTICLE

Influence of hot arid climate on the use of outdoor urban spaces and thermal comfort

Do cultural and social backgrounds matter?

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Climate-sensitive open spaces within cities may have a positive effect on economic, social and environmental aspects of the urban environment. Improvement of microclimatic conditions in urban spaces can enable people to spend more time outdoors, with the potential to influence the social cohesion of a space and increase economic activity. The wider aim of this research is to develop a better understanding of the complex relationship between the microclimate and human behaviour in open public spaces in hot arid climates. Case studies are selected in two different parts of the world (Marrakech in North Africa and Phoenix, Arizona in the US) to represent a variety of users in a similar climatic context. This enables the authors to study the effects of socio-economic and cultural diversity on thermal comfort, behaviour and use of space. Field surveys include structured interviews with a standard questionnaire and observations of human activities, along with microclimatic monitoring, carried out during the summers and winters of 2008 and 2009. The analysis consists of: microclimatic influence on thermal sensation, preference and people attendance; effect of psychological adaptation on the subjective thermal evaluation of outdoor spaces; and investigation of socio-economic and socio-cultural impact on the behaviour of people in outdoor spaces.

Keywords: hot climate; microclimate; outdoor thermal comfort; socio-culture; urban design

INTRODUCTION

As the number of inhabitants in urban areas increases, the need for good open places within cities increases too. This should improve the environmental quality of cities in which people live and work every day and should eventually improve their quality of life. Recently, therefore, there has been increased interest in research that focuses on thermal comfort in outdoor settings. Users' state of comfort can often indicate the success of public urban spaces. In extreme climatic conditions in particular, such as in hot arid climates, the thermal state of users plays an important role in the success of urban open spaces.

There has been lack of research focusing on issues of thermal comfort in outdoor settings, particularly field studies. Moreover, most of

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 ISSN: 1750–8975 (print), 1756–6932 (online) www.earthscan.co.uk/journals/inbi

the work has been carried out in developed countries, where the majority of people spend most of their time indoors (Spagnolo and De Dear, 2003). Research in this area has concentrated on aspects such as the relationships between thermal comfort, microclimate, behaviour and use of place, and spatial variation (Spagnolo and De Dear, 2003; Nikolopoulou and Lykoudis, 2006, 2007; Thorsson et al., 2007). The psychological variables related to the thermal comfort of users in outdoor places have also been the focus of a number of studies (Nikolopoulou et al., 2001; Nikolopoulou and Steemers, 2003; Thorsson et al., 2004; Nikolopoulou and Lykoudis, 2006). Recently, research has focused more on dealing with the association between culture and climatic characteristics that influence the use of outdoor spaces (Knez and Thorsson, 2006; Knez et al., 2007; Thorsson et al., 2007) but all the studies were conducted in temperate or cold climates.

This article presents the initial results of a study conducted in outdoor spaces in hot arid climates. The wider aim of this research is to develop a better understanding of the complex relationships between microclimate and human behaviour in open public spaces in hot arid climates, taking into account socio-economic background and cultural differences. Case studies were carefully selected in two different parts of the world – Marrakech in North Africa and Phoenix, Arizona in the US – to represent different cultural backgrounds in a similar climatic context. This enabled study of the effects of socio-economic and cultural diversity on thermal comfort, behaviour and use of spaces.

METHODOLOGY

Field surveys were carried out during the summers and winters of 2008 and 2009 on the dates and times shown in Table 1. Samples were studied in their 'real-world settings' in order to include the full complexity of conditions that subjects experience in each site investigated in this study. Data collection included environmental and human monitoring.

ENVIRONMENTAL MONITORING

The environmental monitoring focused on measuring the four classical thermal parameters that are renowned for their impact on thermal sensation. These parameters are air temperature, wind speed, solar radiation and relative humidity. A portable set of instruments was used to monitor the conditions the subjects were exposed to. The conditions were measured as follows:

- air temperature and humidity were measured using a Rotronic temperature and humidity probe;
- globe temperature was measured with a globe thermometer which has a 38 mm diameter grey table-tennis ball covering a thermocouple wire;
- solar radiation was measured using a standard pyranometer;
- wind speed was measured using a low-power anemometer with a compact cup-star wind transmitter; and
- a Squirrel 1001 data logger was used to log the data.

Sensors were selected to conform to ISO 7726 (1985) and fixed on the top of an adapted case shown in Figure 1, while the data logger and power supply were located inside it.

HUMAN MONITORING

Two approaches were used for human monitoring. The researcher observed people and activities on sites – an observation sheet was prepared for each site and filled in every 20 minutes. In addition, people participated directly in the study by responding to questionnaires through structured interviews.

The questionnaire included four parts. The first part investigated the evaluation of different climatic parameters, thermal sensation and preference of subjects. The second part investigated various aspects of physical and psychological adaptation as well as evaluation and use of space. It also included wider aspects, such as the influence of climatic contexts,

TABLE 1 Dates and times of filed surveys

City	Season	Site	Date			Time		
			Year	Month	Days	Morning	Noon	Late afternoon
Marrakech	Winter	K. Park	2008	Feb	01,*03*,05,07,	08:00–10:00*	12:00–14:00	15:00–17:00
Marrakech	Winter	K. Plaza	2008	Feb	*02*,04,06,08,	08:00–10:00*	12:00–14:00	15:00–17:00
Marrakech	Summer	K. Park	2008	Jul	22,24,25,	08:00–10:00	12:00–14:00	17:00–20:00
			2008	Aug	*02*			
Marrakech	Summer	K. Plaza	2008	Jul	22,24,25,	08:00–10:00*	12:00–14:00	17:00–20:00
				Aug	*02*			
Phoenix	Winter	Ch. Park	2009	Jan	11,12,13,20	08:00–0:00	12:00–14:00	15:00–17:30
Phoenix	Winter	T. Lake	2009	Jan	08,09,*10*	08:00–10:00	12:00–14:00	15:00–17:30
Phoenix	Winter	T. Market	2009	Jan	15,16,*17*	08:00–10:00*	12:00–14:00	15:00–18:30
Phoenix	Summer	Ch. Park	2008	Jun	27,*28*,30	08:00–10:00	12:00–14:00	17:00–19:30
				Jul	01			
Phoenix	Summer	T. Lake	2008	Jul	*06*,07,08,09	08:00–10:00**	12:00–14:00**	17:00–20:00
Phoenix	Summer	T. Market	2008	Jul	*06*,08,09	08:00–10:00*	12:00–14:00	17:00–20:00

* Most interviews were conducted after 12:00 as the site was deserted before that.

** Most interviews were conducted in late afternoon as the site was deserted before that.

Dates in italic represent weekends.

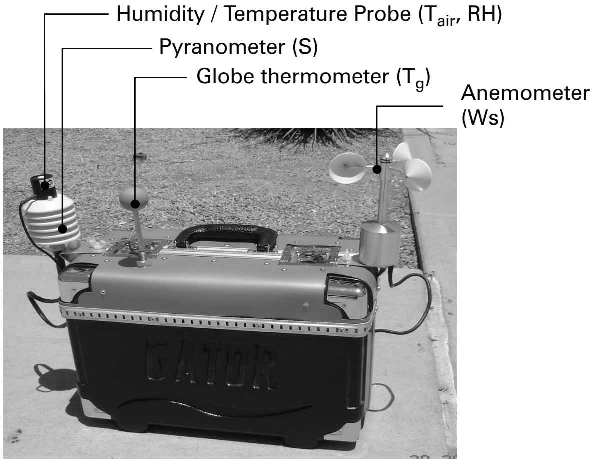

FIGURE 1 Mini weather station used in field surveys

for example, where subjects used to live during their childhood, recent thermal history, etc. The third part of the questionnaire was designed to evaluate subjects' socio-economic conditions. Three questions about educational level, job type and financial abilities (Platt, 2006) were used to rank subjects according to their socio-economic background. The final part of the questionnaire collected observation data such as age, gender, clothing, etc.

STUDY AREAS

To meet the objectives of this study, the selected sites had to be located in a hot arid climatic zone. And to ensure participation by people from different socio-cultural backgrounds, cities in different parts of the world were selected that were representative of the North African and the Western culture lifestyles. This enabled an examination of the effects of cultural differences on thermal sensation and use of outdoor spaces. These cultural differences include: clothes, privacy, patterns of use including time, number of people and their activities. In addition, different space typologies enabled an exploration of how design affects the use of space through the creation of different microclimates. Therefore, five sites were carefully selected in two different parts of the world (Marrakech in North Africa and Phoenix, Arizona in the US), as shown in Figure 2.

Marrakech is located in the western part of North Africa at 31°62′N 8°03′W, in an area between the dry semi-arid and the dry arid zone and its altitude is 450 m. The two sites in Marrakech, a park and a plaza shown in Figures 2.1 and 2.2, are located close to the historical Mosque of Al Koutoubia near the centre of the old city of Marrakech. Site 1 – Al Koutoubia Park – offers more shaded benches, whereas site 2 – Al Koutoubia Plaza – has very few and most of them are not shaded. Meeting, watching and chatting with other people are the most frequent activities in sites 1 and 2.

Phoenix is located in the Salt River Valley in central Arizona at 33°26′N 112°1′W, in the dry arid climatic zone and its altitude is 342 m. Three sites were selected in Phoenix: site 3, Chaparral Park in Scottsdale shown in Figure 2.3; site 4, Tempe Beach Park shown in Figure 2.4; and Tempe Marketplace in Tempe shown in Figure 2.5. Sites 3 and 4 are parks and suitable for sports and physical exercise as well as recreational activities such as cycling, jogging, skating, picnics, etc. Site 3 offers more shaded areas, whereas site 4 offers more water-related

FIGURE 2 Case study areas

activities e.g. fishing, water slides, canoeing, etc. Site 5, Tempe Marketplace, is a modern outdoor shopping mall, opened in 2007. It was designed to provide visitors with improved microclimatic conditions in hot conditions. In addition to the compact blocks and narrow paths and spaces, various techniques such as providing extensive shading devices and water sprinklers are used, as shown in Figure 2.5.

RESULTS

The analysis presented below includes the data collected from both cities, in summer and winter. 429 interviews were carried out, 247 in the winter and 182 in the summer, including 86 females and 343 males. In Marrakech, there were 186 interviews in the winter and 117 in the summer, while in Phoenix, there were 65 in the summer and 61 in the winter. The reason why the number of interviews in Phoenix is small is because of the small number of people found outdoors. The sites studied were used by different age groups as shown in Table 2. In the following sections, the initial results of this study will be discussed under three categories:

- microclimatic impact on human behaviour;
- thermal sensation and comfort;
- effects of socio-economic and socio-cultural backgrounds.

MICROCLIMATIC AND HUMAN BEHAVIOUR

The average microclimatic variables were measured at sites while interviews and observations were taking place in both winter and summer, as presented in Table 3. It is apparent that air temperature was very high in both cities throughout the year, with a summer mean air temperature of 35°C in Marrakech and 39°C in Phoenix, as shown in Table 4. Such a very high air temperature would clearly reduce outdoor activities in a northern or even temperate climate. The winter mean air temperature was at a more comfortable level 20°C in Phoenix and

TABLE 2 Age distribution of interviewees

Age group	<18	18–24	25–34	35–44	45–54	>55
Percentage (%)	3.8	25	30.6	19	11.5	10.2

TABLE 3 Average microclimatic variables for Marrakech and for Phoenix

			T_g (°C)	T_{air} (°C)	RH (%)	Ws (m/s)	S (W/m^2)
Marrakech	Site 1	Winter	22	23	32	0.7	258
		Summer	36	37	24	1.0	307
	Site 2	Winter	23	24	26	0.9	263
		Summer	35	36	26	1.2	309
Phoenix	Site 3	Winter	18	18	34	0.6	262
		Summer	39	39	24	1.2	381
	Site 4	Winter	18	17	39	0.7	245
		Summer	41	41	23	1.3	229
	Site 5	Winter	18	18	34	0.6	262
		Summer	41	41	27	0.9	536

TABLE 4 Measured air temperature in Marrakech and Phoenix in winter and summer

Air temperature T_{air} (°C)					
		Min	Max	Mean	SD
Marrakech	Winter	12	28	22	3.3
	Summer	29	41	35	2.9
Phoenix	Winter	5	31	20	6.9
	Summer	31	47	39	4.1

22°C in Marrakech. Relative humidity was low throughout the year for both cities.

Solar radiation appears to have the greatest negative influence on both attendance and activities in summer time, as can be seen in Figure 3. The relationship between the number of people in the space and solar radiation (S) was found to be negatively and strongly related in site 5, Tempe Marketplace ($r = -0.922$, $P<0.001$). Thus, as the intensity of solar radiation increases,

FIGURE 3 Effect of solar radiation on attendance: A – overcast; B – sunny

the number of people in the place decreases. Negative but medium correlations were found between the number of people in the place and solar radiation (S) in sites 1, 2 and 3 – Al Koutoubia Park, Al Koutoubia Plaza and Chaparral Park (–0.685, $P<0.001$; -0.605, $P<0.001$; -0.488, $P<0.001$, respectively). In order to interpret the results above, it is necessary to note that the spaces in sites 1, 2 and 3 are relatively open compared with site 5 (Tempe Marketplace); the few shaded areas are confined under trees. In addition, sites 1, 2 and 3, unlike site 5, are not provided with air-conditioned premises such as nearby shops and cafes. Therefore, under these conditions, people in sites 1, 2 and 3 may be tolerating the solar radiation more than in site 5, where air-conditioning is an easy option. Site 4 has similar conditions to sites 1, 2 and 3. However, water activities in site 4 attract people throughout the day. This is probably the reason why there is no significant correlation between the number of people and solar radiation in this space.

Similarly, the number of activities in the place, such as chatting, eating, reading, fishing, walking a dog, etc., was found to be negatively and strongly correlated with solar radiation (S) in site 5, Tempe Marketplace ($r= -0.867$, $P<0.001$). Therefore, as the intensity of solar radiation increases, the number of activities decreases. Negative and medium correlations were found between the number of people in the place and solar radiation (S) in sites 1, 2, 3 and 4 – Al Koutoubia Park, Al Koutoubia Plaza, Chaparral Park and Tempe Beach Park (-0.462, $P<0.001$; -0.509, $P<0.01$; -0.696, $P<0.001$; -0.638, $P<0.005$, respectively). These differences are probably due to the different aspects of design of these places, as well as the types of activity. For example, in site 5 (Tempe Marketplace) people prefer to sit inside the nearby air-conditioned cafes and restaurants, rather than sitting on the seats provided in the outdoor space during and the middle of the day and the afternoon. People start moving out, using the outdoor public seats in the late afternoon and evening when the space is almost fully shaded. On the other hand, in site 4 (Tempe Beach Park), people tend to stay outdoors, particularly around the water splash area. Although water activities in this site are mainly for children, parents and carers are involved in other activities such as eating and drinking, reading, etc.

The thermal preference of people differs between sites and seasons. In summer, more than 60 per cent of users in both cities preferred to be cooler, as shown in Figures 4 and 6. Although the mean air temperature was slightly higher in Phoenix – 39°C compared with 35°C in Marrakech, as shown in Table 4 – an average of 30 per cent of the people in Phoenix sites preferred being warmer, as shown in Figure 6. This will be discussed in the next section 'Thermal sensation and comfort'.

In Marrakech, people tended to avoid being in the plaza before the late afternoon when the air temperature and solar radiation decreased. The park, as opposed to the plaza, attracted more people during times of the day when both the air temperature and solar radiation were peaking, as well as in the late afternoon and evening, because it offers suitable seating areas in the shade.

In winter, around 60 per cent of the interviewees in Marrakech did not prefer to change their thermal conditions. More people in the plaza preferred being cooler compared with those who preferred being warmer, 25 per cent and 17 per cent, respectively. On the other hand, more people in the park preferred being warmer compared with those who preferred being cooler, 25 per cent and 15 per cent, respectively, as seen in Figure 5. The plaza was open and more exposed to the sun with few shaded areas, thus the interviewees had better access to solar radiation. In the park, however, seats were mostly shaded by trees and the interviewees were unlikely to find seats in the sun. In Phoenix, the thermal preferences of the interviewees were also dependent on the nature of the space they were in. For example, those who were interviewed in open areas such as Chaparral Park and Tempe Lake preferred to be warmer. In contrast, those interviewed in Tempe Marketplace, where the space was

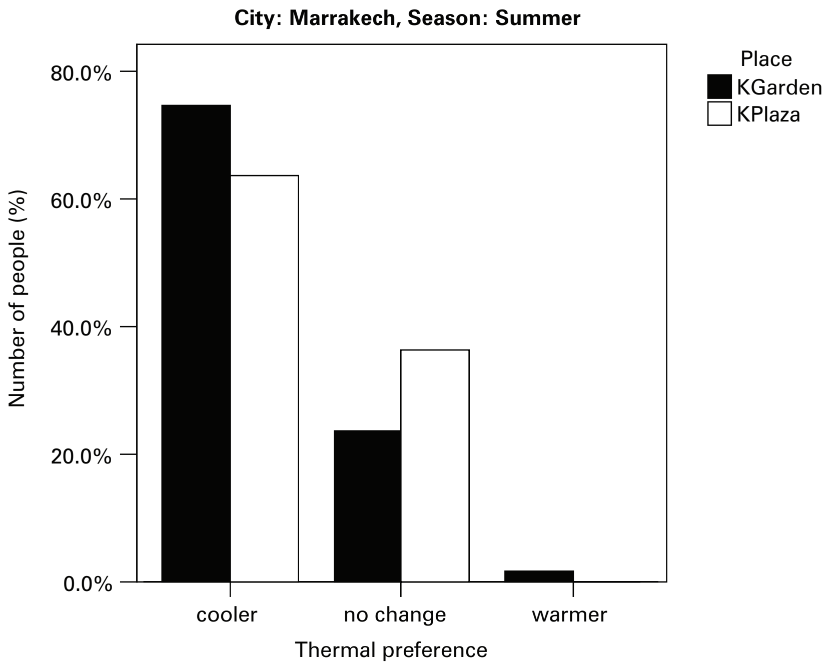

FIGURE 4 Thermal preferences in Marrakech (summer)

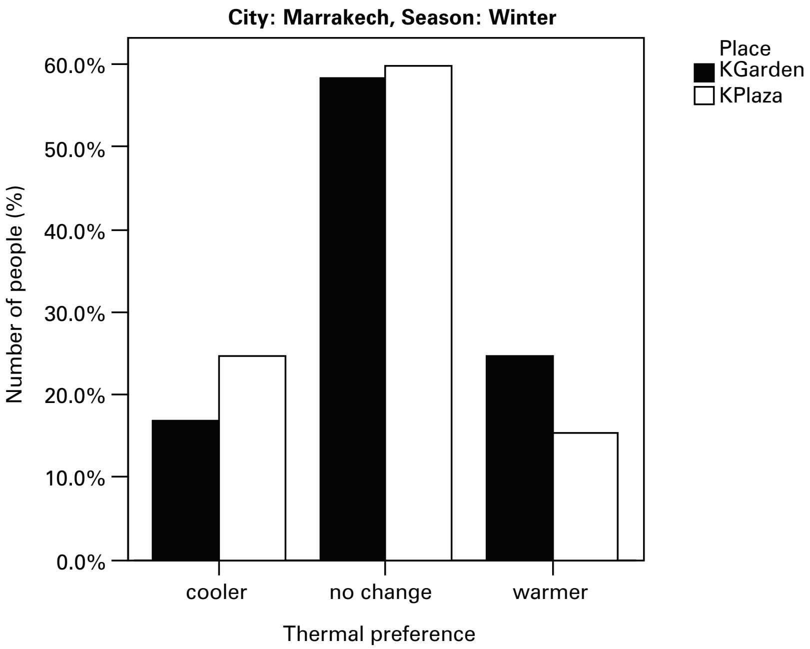

FIGURE 5 Thermal preferences in Marrakech (winter)

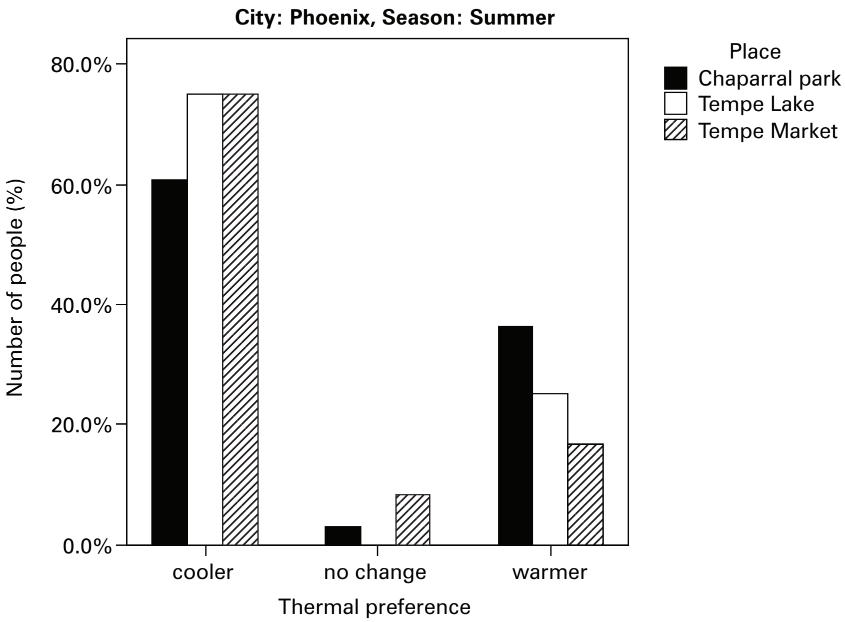

FIGURE 6 Thermal preferences in Phoenix (summer)

narrow and protected from wind, preferred to maintain their current thermal condition, as shown in Figure 7.

In conclusion, solar radiation influenced both the number of people and the number of activities outdoors, particularly in the summer.

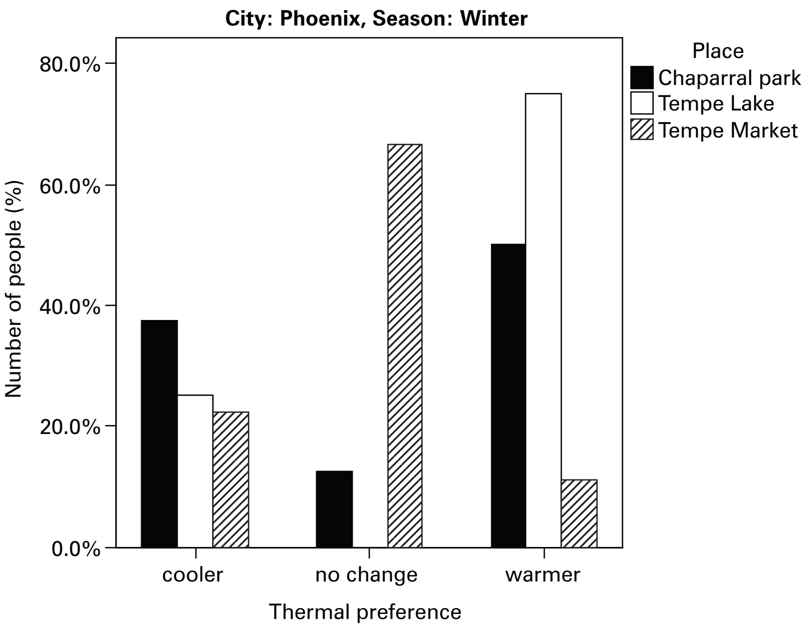

FIGURE 7 Thermal preferences in Phoenix (winter)

Thermal preferences of people were found to be varied between different sites and seasons. Thus, sites that provided shelter from intensive solar radiation were more popular around midday compared with sites with less or no shaded seats. This highlights the important role of design of open spaces in hot arid climates in providing acceptable microclimatic conditions at different times of the year.

THERMAL SENSATION AND COMFORT

Thermal sensation has been examined in two different ways – subjective and objective. People were asked to evaluate their thermal sensation at the time of the interview on a five-point scale, varying from hot to cold (actual sensation vote – ASV). This was then compared with Fanger's model, the theoretical predicted mean vote (PMV), as defined by ISO 7730 (2005). The PMV model predicts thermal sensation as a function of six parameters: air temperature, mean radiant temperature, air velocity, humidity, clothing and activity. The first four environmental parameters were measured during the interviews. Clothing levels were observed and registered on the questionnaire form, while the values of thermal insulation of clothing were later estimated according to ISO 7730 (2005). Metabolic rates were also estimated from the observed activities, according to the same standard document.

The PMV model has been used frequently to underline the effect of adaptation in outdoor settings. However, it is important to highlight that the PMV model was intended for indoor, fully conditioned buildings. According to the steady-state heat-balance theory, the human body is a passive recipient of thermal stimuli (Brager and de Dear, 1998) and the PMV does not take adaptation opportunities into account. More recently, studies have been conducted to widen the applicability of the original PMV (van Hoof, 2008). For example, Fanger and Toftum (2002) introduced an extension to the PMV by proposing an expectancy factor 'e' to explain the overestimation of thermal sensation in non-air-conditioned building in warm climates. Yao et al. (2009) have considered factors such as culture, climate, and social, psychological and behavioural adaptations in developing the adaptive predicted mean vote (aPMV) model. All these strengthen the argument that a purely physiological approach cannot adequately characterize thermal comfort conditions; other socio-cultural and psychological parameters become increasingly important. The PMV, however, is not yet appropriate for use outdoors.

The percentage frequency distribution for PMV and ASV of the interviewees has been calculated for both cities and the different seasons and is presented in Figure 8. It is clear that there is great inconsistency between the ASV and PMV curves; around 60 per cent of the PMV curve falls outside the theoretical comfort conditions (-1 to +1), around 40 per cent feel hot and 20 per cent feel cold. However, the ASV curve shows that only 20 per cent fall outside the actual comfort conditions, mainly in the hot region (+2). The graph also illustrates that the majority of those who have voted within the actual comfort conditions (-1 to +1), have voted for neutrality or the warm part of the scale (0 and +1). Conversely, the theoretical curve shows that the majority of votes within the predicted comfort conditions (-1 to +1), fall within the cool (-1) and neutral (0) part of the scale.

Fanger's model, which is based on laboratory and climate chamber research, is very dependent on thermal neutrality, which does not necessarily have to correspond to the desired or preferred thermal sensation (Humphreys and Hancock, 2007). Nevertheless, the actual thermal sensations and preferences of people in the conditions of this research can be explained more fully by means of the adaptive approach to thermal comfort. Brager and de Dear (1998) have stated that one prediction of the adaptive approach to thermal comfort is that people in warm climate zones prefer warmer indoor temperatures than people living in cold climate zones. In this study, people had past experience and familiarity with warm and hot conditions. Some of them had long-term exposure to uncomfortable indoor conditions, such as living or working in non-air-conditioned spaces. Thus

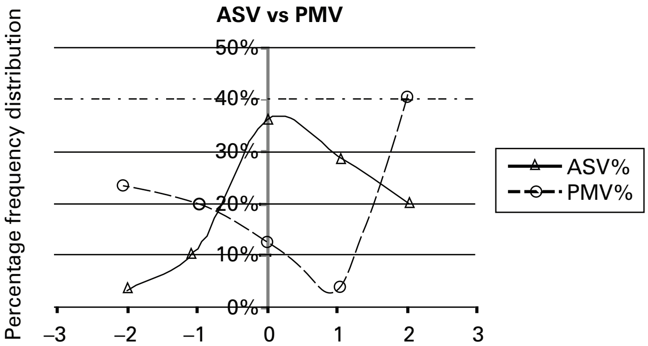

FIGURE 8 Percentage frequency distribution of the actual sensation vote (ASV) in summer and winter (all sites)

it became apparent why people tolerate feeling warm in outdoor spaces, as shown in Figure 8.

In Marrakech for example, many interviewees complained about the poor thermal conditions in their houses; the houses were very hot, especially in the evening. Consequently, they used the open spaces as somewhere to escape to, where they could find cooler conditions. Furthermore, apparently, people not only tolerated but enjoyed feeling warm. In Phoenix, as opposed to Marrakech, around 30 per cent of those who were interviewed in summer preferred to be warmer, as shown in Figure 9, despite very hot conditions as shown in Table 4. The interviewees were under these conditions for a substantial amount of time. People's average daily exposure to the outdoor conditions was 90 minutes in Phoenix and 55 minutes in Marrakesh. This may also be to the result of people seeking environmental stimulation and some cultural differences.

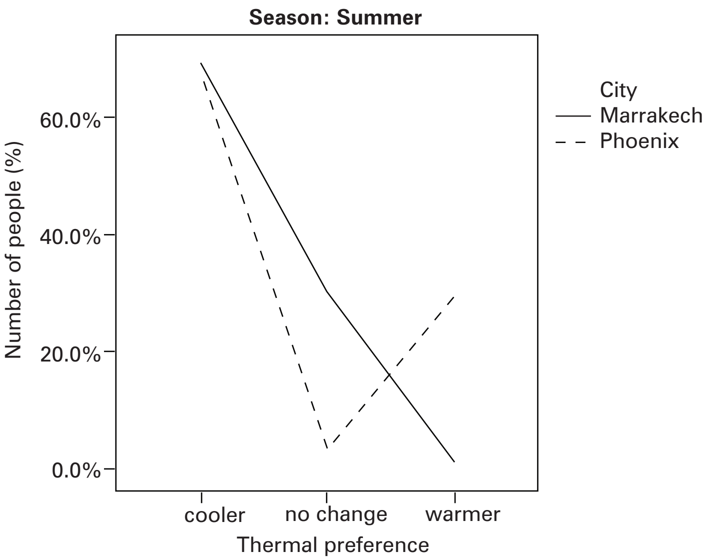

FIGURE 9 Thermal preferences in Phoenix and Marrakech, summer

Given that air-conditioned interiors are widespread in Phoenix, people spend much more time in artificially cooled spaces (home, work and cars). Therefore, people appreciate the environmental stimulation offered outdoors, particularly when the site itself offers different kinds of stimulation. In those circumstances, people will have higher tolerances to extreme conditions, provided they are not threatening, than they would under average circumstances (Nikolopoulou and Steemers, 2003).

It could be argued that the interviewees had been exposed to the hot conditions for only a very short time after coming out of an air-conditioned building. However, looking at their history of exposure to air conditioning prior to the interviews reveals interesting information. In Phoenix, 75 per cent of the interviewees had not been under the effect of air conditioning for at least 30 minutes before the interview. Only 8 per cent of the interviewees in Phoenix reported being under the effect of air conditioning less than 15 minutes before the interview took place. Most of them were in Tempe Marketplace, where indoor air-conditioned stores, restaurants, cafes are conveniently accessible.

In Marrakech, 90 per cent of the interviewees had not been under the effect of air conditioning for at least 30 minutes before the interview. In fact, 85 per cent of the interviewees had not been exposed to air conditioning for at least 90 minutes before the interview. In addition, most of the interviewees in Marrakech reported not having any air-conditioning systems installed at their homes or where they worked.

Hence it became apparent that thermal sensation and thermal comfort of the interviewees reported in this study are unlikely to be transient because the vast majority of interviews took place well after the interviewees had been into air-conditioned spaces.

Some culture-related issues such as clothing may help to understand this phenomenon. It was observed that people in Phoenix tend to wear lighter clothes in summer e.g. T-shirts, shorts, short skirts, etc. However, in Marrakech, because of the cultural rules, people tend to wear clothes that cover most of their bodies for both genders. The mean clothing insulation of the interviewees was 0.35 clo in Phoenix compared with 0.70 clo in Marrakech, calculated for both seasons. Therefore, it is unlikely that people in Marrakech were seeking any further increase in their thermal condition under the summer conditions shown in Table 4.

Another interesting comparison is the time people spent in the different areas. It seems that the interviewees who considered the weather conditions typical for the season tended to spend more time in the space. Those who did not consider the conditions as typical, or had no idea about the climatic conditions of the area at the time of the interview, spent less time in the space, as shown in Figure 10. This is probably due to the unpleasant thermal conditions that they were not used to. People were asked about the time they usually spend outdoors and indoors during weekdays; they were divided accordingly into two groups, 'outdoors individuals' and 'indoors individuals'. Those who usually spend more time outdoors or the 'outdoors individuals' tend to stay longer in the studied sites compared with the 'indoors individuals' who spend more time indoors, as shown in Figure 11. This is probably because of the familiarity of the 'outdoor individuals' with the outdoor conditions and respective thermal conditions.

SOCIO-ECONOMIC AND SOCIO-CULTURAL EFFECTS

Three factors were chosen to classify subjects into three groups based on their socio-economic background – education, job and self-evaluation of the economic state of the interviewee (Platt, 2006). The lower band includes those with a basic education, jobless or with low income and their financial situation was described as 'quite or very difficult'. The upper band consists of people who had a higher education, highly skilled jobs and their financial situation was described as 'all right' or 'living comfortably'. Those in the middle between these two groups were included in the mid band. For each city, the mean number of

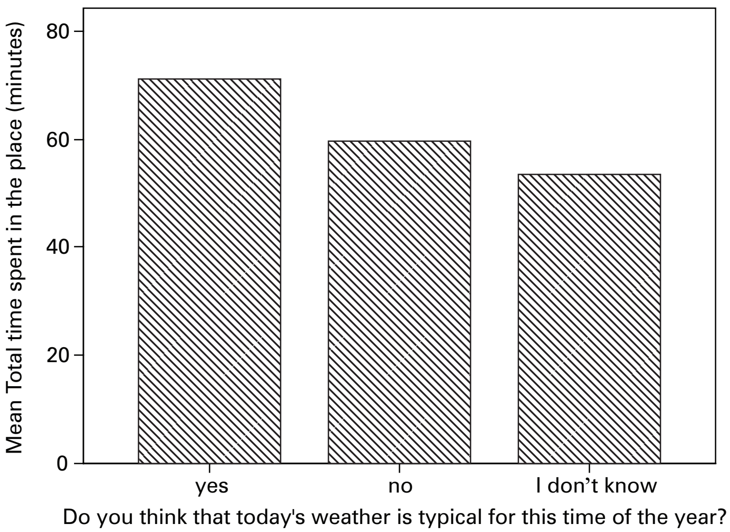

FIGURE 10 Mean time (in minutes) spent in place as function of weather expectation

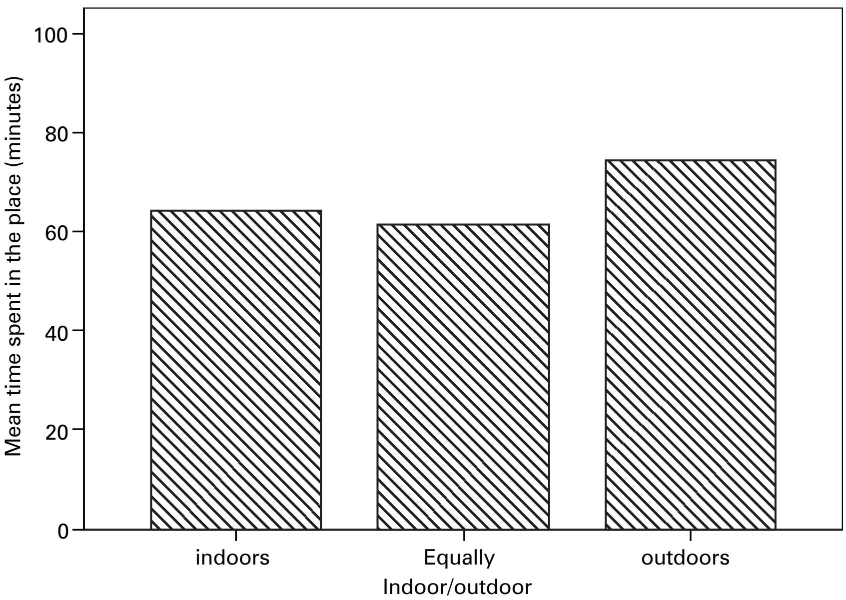

FIGURE 11 Mean time spent in place as function of the time usually spent indoors or outdoors

people from each social group is compared with the mean total time spent in the place, taking into account that time spent a space can be regarded as one indicator of satisfaction with the conditions of a place (Gehl, 2006).

It appears that people belonging to the lower band spent more time in the outdoor spaces, compared with those who belong to the upper band. For example, the mean time spent by people in Phoenix from the lower band was around 140 minutes, whereas the mean time spent in the same sites by people from the upper band was around 80 minutes, as shown in Figure 12. It is unlikely that these socio-economic groups differ in the time they spend outdoors due to a difference in their perceptions of the place. All three groups have similar perceptions in terms of interesting or boring, as shown in Figure 13. It could be argued that thermal conditions, particularly solar radiation in this case, influence the time spent by each of these socio-economic groups in the place. When the intensity of solar radiation decreases, time spent in the outdoor space increases, as

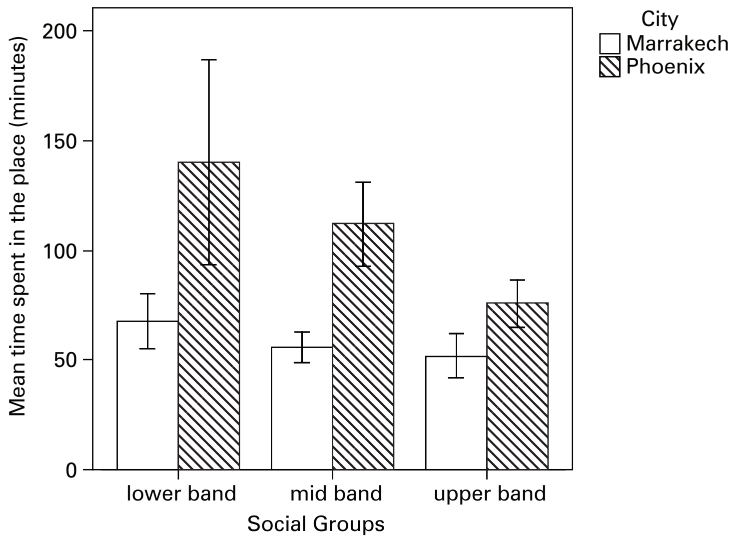

FIGURE 12 Mean time spent in place as function of social groups

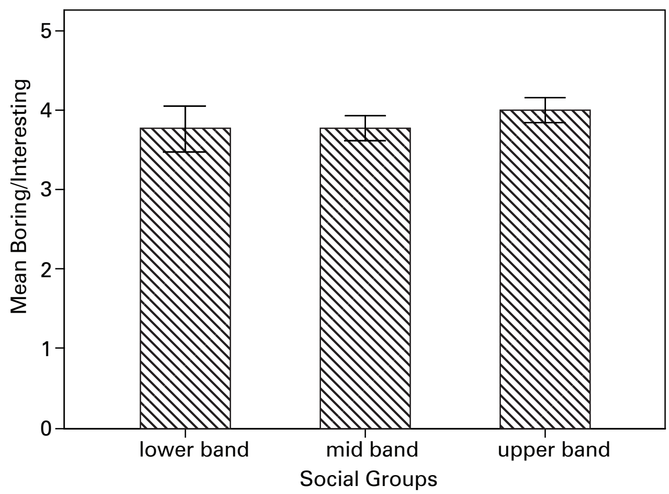

FIGURE 13 Place perception (boring/interesting) as function of social groups

shown in Figure 14. This may be due to the fact that people in better financial situations have the option to move indoors to an air-conditioned space, unlike those who cannot easily afford such 'luxuries'.

The impact of cultural differences appears in the patterns of use, activities and ways of adaptation. The number of people who visited the sites in Marrakech was higher than the number of people found in Phoenix, as shown in Figure 15. People in Marrakech tend to visit the sites in large groups and families. They sit in groups and chat or watch others. In Phoenix, people tend to visit the sites in smaller groups or individually. However, the range of activities carried out is wider, as shown in Figure 16. The variety and number of activities may explain why people spent more time in the sites in

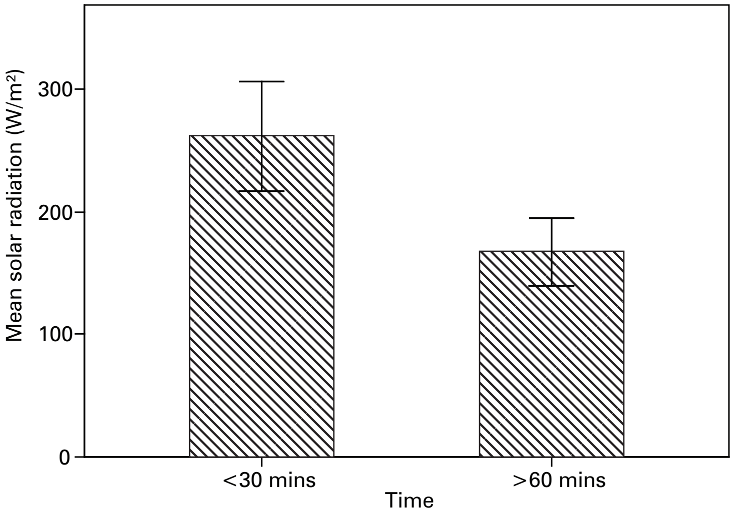

FIGURE 14 Solar radiation (W/m²) as function of time spent in place

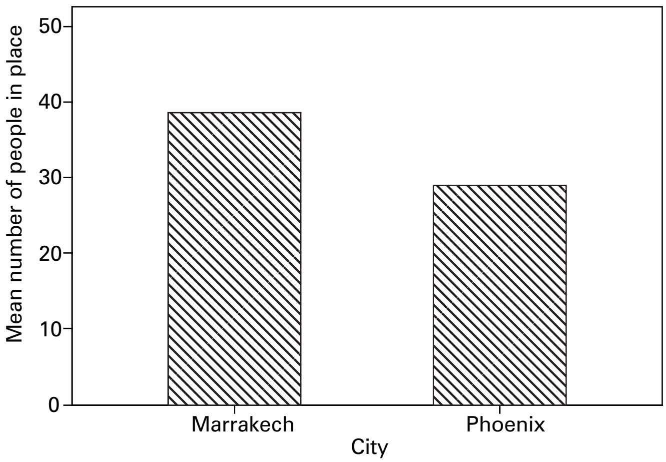

FIGURE 15 Mean number of people in the investigated sites in both cities

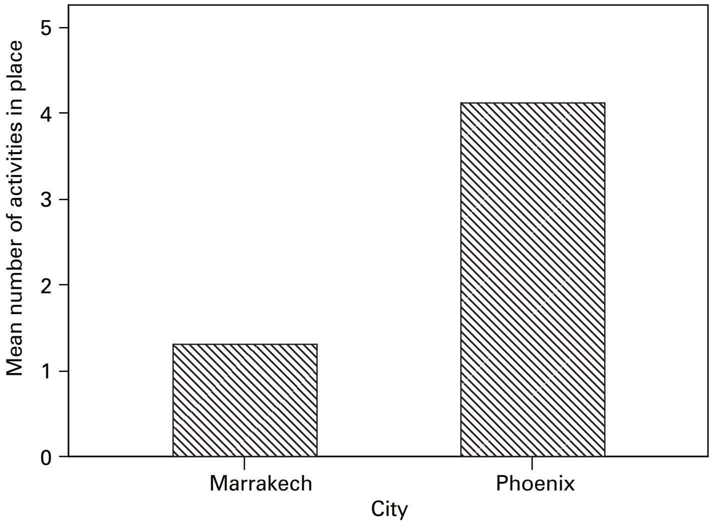

FIGURE 16 Mean number of activities in the spaces in both cities

Phoenix compared with Marrakech, as shown in Figure 17. Moreover, people in Phoenix wear lighter clothes in summer e.g. T-shirts, shorts, short skirts, etc., whereas in Marrakech, people tend to wear clothes that cover most of their bodies for both genders, according to cultural rules in Marrakech, see Figure 18. As discussed earlier in 'Thermal sensation and comfort', these cultural differences had a significant effect on the thermal sensation and comfort conditions of the interviewees and their use of outdoor spaces in both cities.

Another difference that was noticed between the two cultures is in the type of activities. More than 80 per cent of the people in Marrakech were sitting, with less than 10 per cent standing in the area and very few walking or running. In Phoenix, on the other hand, around 44 per cent

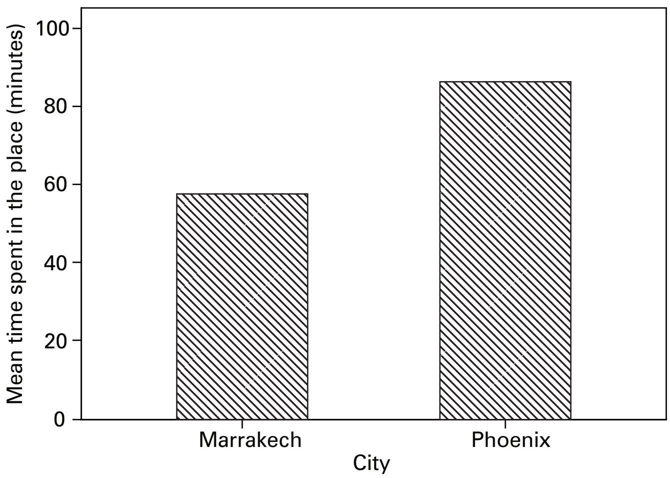

FIGURE 17 Mean time spent in the space in both cities

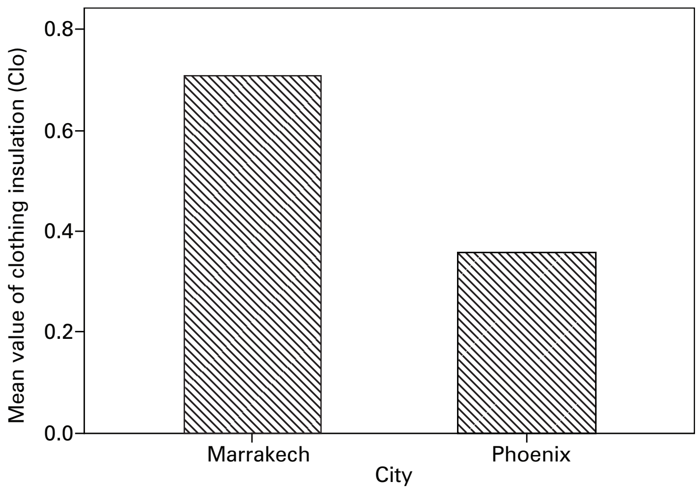

FIGURE 18 Mean clothing insulation values for people in both cities

of the people were sitting, around 35 per cent walking, around 20 per cent standing and some jogging, as shown in Figure 19.

Moreover, as mentioned earlier, people in Phoenix spent more time in air-conditioned spaces. Around 75 per cent of those interviewed in Phoenix in the summer were in an air-conditioned space less than one hour before the interview compared with 25 per cent in Marrakech, as shown in Figure 20. It is very

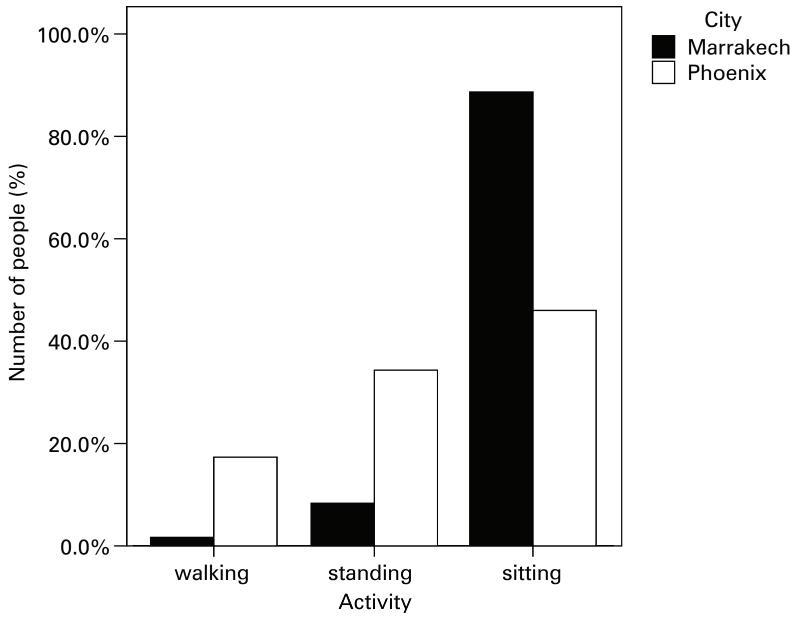

FIGURE 19 Activities by the interviewees for the last 10 minutes before the interview

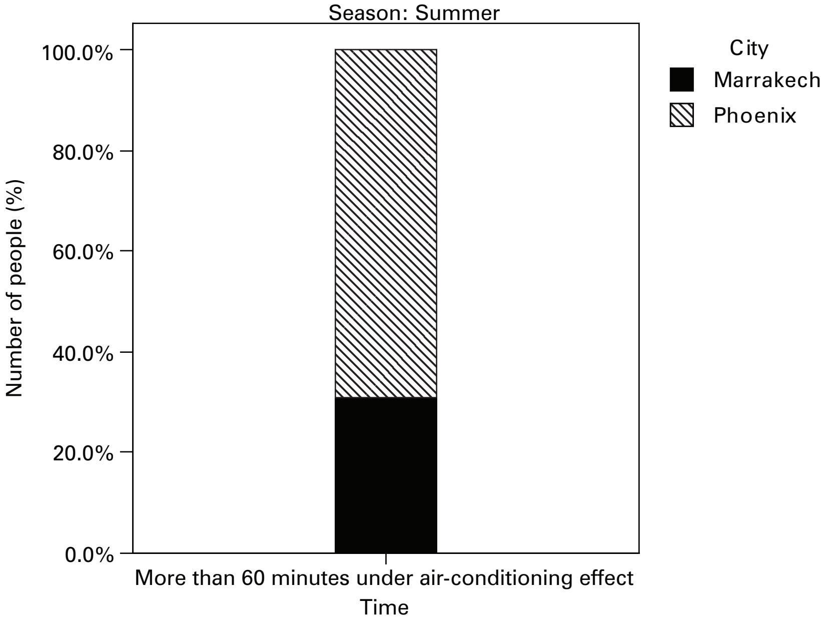

FIGURE 20 Exposure to air-conditioning before the interview in both cities

unlikely to find a non-air-conditioned public building or public transportation in Phoenix. Conversely, in Marrakech, the majority of interviewees arrived at the studied sites either by walking or by using non-air-conditioned public transportation.

In addition, people tend to use the observed places not only when the environmental conditions allow them to do so but also, for many of them, when these places fulfil other social and individual needs. For example, some people have a tendency to occupy parts of outdoor spaces when others are around. Other people commented on the need to have wider private space while looking at other people. Others prefer places that offer events, especially when the outdoor comfort conditions become unbearable. Finally, when the environmental conditions were not very welcoming, the ability of the place to host various activities encouraged people to visit and stay, even at midday in the summer.

CONCLUSION

This article presents some of the initial findings of a study on thermal comfort in hot arid climates, working towards understanding the relationship between place microclimate and human behaviour. It has been found that solar radiation influences the number of people and activities outdoors particularly in the summer.

In line with different climatic contexts, the findings support the theory that a purely physiological approach is not enough to describe human thermal comfort in outdoor spaces. Some people have a tendency not only to tolerate but to enjoy feeling warm in outdoor spaces in the hot arid climate, where this study was conducted. This may be attributed to their experience and familiarity with warm and hot conditions. Some of them had long-term exposure to uncomfortable indoor conditions such as those who live or work in non-air conditioned spaces. Many people in Phoenix, where air-conditioned interiors are widespread, spent a longer time in artificially cooled spaces. In that case, seeking environmental stimulation could also explain why some people in Phoenix had an extensive tolerance level of high temperatures.

There was an association between the time spent in outdoor spaces and the individual expectation of the climatic conditions in the relevant area. Hence, people who considered weather conditions to be typical on days of interviews, spent more time in outdoor spaces. Conversely, those who did not consider it to be typical and those with less knowledge about the climatic conditions in the area at that particular time of the year, spent less time in outdoor spaces.

It seems that those who have a higher level of education, and better job and financial circumstances, are more sensitive to environmental conditions. Therefore, thermal conditions influence the time spent by different socio-economic groups in the place concerned. When the intensity of solar radiation decreases, time spent in the space increases. This may be due to the fact that people with more secure financial circumstances have the option to move indoors to an air-conditioned space, unlike those who cannot easily afford such 'luxuries'.

In this climatic context, people from different cultures have differences in the way they use outdoor spaces. These differences include type and number of activities, the presence of other people and privacy which eventually influence the time spent outdoors as well as their acceptability of the thermal conditions.

Finally, design is an important parameter that can significantly improve microclimatic conditions, critical in the climatic context outlined above. It is important that outdoor spaces in hot climate zones are designed to host various activities to encourage people to visit and stay longer.

ACKNOWLEDGEMENTS

This research has been funded by the Department of Architecture and Civil Engineering, University of Bath. We would also like to thank Professor Harvey Bryan, Professor Jacques Giard and Mr Akram Roshidat from the College of Design, Arizona State University for their invitation and hospitality.

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