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Spatial and activity preferences during heat stress conditions in Adelaide: towards increased adaptation capacity of the built environment

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Abstract

Outdoor thermal discomfort pushes citizens into air-conditioned buildings and causes increased demand for water and electricity in the majority of Australian urban heat islands. Citizens' spatial and activity preferences during heat stress conditions are under investigation in this paper. Citizens' outdoor activity choices in different thermal environments were surveyed in Adelaide from September 2013 to April 2014. The post-activity questionnaire survey of outdoor activities in Adelaide indicates that necessary, optional and social activities decreased during outdoor heat stress more than any other thermal conditions. Outdoor activities were chosen the most in neutral and warm thermal environments. Outdoor activity choices were affected significantly by the urban microclimate parameter of solar radiation. Tree canopy, shading (from buildings or temporary elements) and water features were the most attractive public space features for outdoor participants during heat stress conditions in Adelaide. Meanwhile, essential shopping and dining facilities and social events affect citizens' outdoor activity choices during heat stress conditions. Thus, increased green infrastructures and supportive land uses are a prerequisite of urban transformation towards high-performance built environment in the context of climate change.

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Keywords: Heat stress; outdoor preferences; high-performance public space; thermal discomfort

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1. Introduction

Australia is expecting a likely increase of 3.8°C in its surface temperature by 2090 [1, 2]. During summer, public spaces are frequently warmer than human thermal comfort standards in a majority of Australian Cities [1, 3]. The number of hot days with maximum temperature above 35°C increases from 15.3 in 30-year average to 18.3 in 3-years average in Adelaide [4]. Meanwhile, heat stress can reach up to 10°C in urban settings compared to their peri-urban surroundings – the phenomenon that is well known as the urban heat island effect [5-7].

In response to such substantial extra heat load in cities, citizens increasingly choose to attend air-conditioned buildings. Background research on Australian cities indicates that there is a strong positive (uphill) correlation between ambient temperature and electricity demand when the daily mean temperature is above 22 °C [8]. North American research confirms the high dependency of electricity demand to increased temperature in California with a slightly lower threshold of 18 °C. It also reveals that slightly lower negative (downhill) correlation exists between energy demand and increased temperature below 10 °C [9]. European research reveals that the lower threshold of energy demand temperature dependency varies from 15 °C in cold climates (Germany and Sweden) to 13 °C in temperate climates (Greece and Spain). The corresponding higher threshold is 22 °C in temperate climates [10, 11].

However, discharged heat – generated from indoor air-conditioning – causes ever-increasing outdoor temperatures. In this context, this paper examines the outdoor activity and spatial choices of citizens during heat stress conditions through an exploratory survey in Adelaide, South Australia. It aims to better understand the spatial configuration of high-performance public spaces in the context of climate change.

2. Outdoor activities and urban microclimates

The built environment can effectively alter outdoor activities and simultaneously, it is impacted by people's social and behavioural norms and actions [12, 13]. The concept of 'public space and public life' argues that vibrant public life is the result of quality public spaces and is also a significant contributor in shaping such quality [13-15]. While a comfortable thermal environment can enhance people's choices to attend outdoors, heat stress can cause significant discomfort – altering the frequency and patterns of outdoor activities.

Thermal comfort is defined as the state of mind that expresses satisfaction with the thermal environment [16]. While the surrounding built environment can justify the primary microclimate conditions for thermal comfort, it is the human's perception that justifies if the body is thermally comfortable or it is under thermal stress. Indoor thermal comfort studies result in the development of a number of steady state thermal comfort (SSTC) models, in which thermal comfort preferences are defined based on microclimate factors of air temperature, humidity, airflow and radiation in addition to human's metabolic rate and clothing isolation [17, 18]. However, advanced thermal comfort investigations indicate that the state of adaptation to outdoor microclimates is an influential factor in comfort sensations [19, 20]. Despite the SSTC models, which considers people as passive occupants of the space exposed to external microclimates, the adaptive thermal comfort (ATC) concept argues that thermal comfort contributing factors are beyond the physical environment.

Accordingly, thermal comfort is perceptual and varies depending on the psychological condition of participants, their expectations and adaptation level, their physiological conditions and the microclimate of the space in which they are placed [21-23]. People adapt themselves to microclimate conditions by selective activities such as clothing and sunlight exposure-prevention [24, 25], while the level of social activities can also influence the outdoor thermal comfort sensation [26]. The ATC concept is multi-variable and complex and discuss thermal comfort not only dependent on microclimate physical factors, but also dependent on demographic characteristics such as gender and age, health, psychological states such as happiness and stress [22, 27], adaptive actions (e.g. clothing), and general expectations of the climate [25, 28-30].