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Cooling Effects and Skin Temperature Recovery in Urban Environments

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Exploring Tree Shade: Cooling Effects and Skin Temperature Recovery in Urban Environments

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This paper investigates the daytime microclimate of street trees and their potential cooling effects on pedestrians in a Dutch neighbourhood.

Heat emissions from buildings, traffic, and industrial activities contribute to the warming of urban areas, intensifying the urban heat island effect. Street green infrastructure, like deciduous trees that provide shade, plays a crucial role in reducing heat stress and promoting pedestrian comfort in various domains. However, studying the physiological response to urban shade is challenging due to difficulties in controlling street-level meteorological variables and recruiting participants. We plan to use semi-controlled outdoor methods to study how shade affects bodies, with a limited sample size. This research aims to better understand the role of tree shades in adapting to urban heat and contributing to global goals for climate action (SDG 13), sustainable cities (SDG 11), and health and well-being (SDG 8).

We conducted an explorative biometeorological study using a juvenile tree (*Tilia x europaea*, 12m in height) located in a social housing neighbourhood in Den Haag. The measurement campaign adopted mobile weather stations to gather meteorological data surrounding the Tilia tree. This took place from 10 am to 5 pm on a sunny day in July 2023. Two heat-stress trackers (Kestrel 5400) were used; one was placed in direct sunlight and the other in the shade of a tree. The shaded tracker was relocated every thirty minutes to adjust for the moving tree shade. Two measurements showed how tree shade cools the air by comparing differences in temperature, humidity, globe temperature, and wind speed between sun and shade. Additionally, sixteen iButton thermocron sensors were taped to different body parts of two participants according to international standard (ISO 9886:2004). We tested a sun-shade relay protocol, tracking skin temperature changes as subjects moved and sat between sun and shade every 20 minutes, across fifteen intervals from 11 am to 4 pm.

The preliminary results are two-fold: 1) Heat stress analysis showed maximum UTCI and PET in the sun at around 3:30 pm were 36.3°C and 39.9°C, respectively, with tree shade significantly reducing UTCI by over 10°C and PET by over 15°C. 2) Heat recovery analysis revealed that the maximum skin warming rate in the sun (1.14°C/min) was higher than the cooling rate in the shade (-0.79°C/min). An additional interesting finding is that, while the PET contrast between sun and shade remains constant at 15°C from morning to afternoon, the skin's heat recovery capacity is compromised by approximately 1.24°C in the afternoon, possibly due to the overall increases in PET of around 3°C.

The discussion and conclusions focus on the choice of outdoor thermal indices, particularly for urban shade studies, and their applicability for future research on dynamic thermal comfort and thermal alliesthesia.