Urban heat risk assessment for pedestrians considering thermal environment and physiological change

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As citizens face increasing heat risk due to climate change with urban heat island effect, heat risk assessments in urban have been conducted focusing on thermal diseases related to heatwave of vulnerable people. Although they provided a basis to establish adaptation strategies such as cooling centers, they could not consider citizens' daily thermal comfort of diverse groups. Thermal comfort could be a part of heat risk because associated with work performance such as productive capacity as well as health. In particular, pedestrians' thermal comfort can represent daily heat risk of outdoor urban environment. The past studies of pedestrians' thermal comfort were evaluated using PMV (Predicted Mean Vote), an index based on temperature, wind velocity, relative humidity and a fixed number of metabolic rate depending on the subject's activity level. The PMV ranges from -3 to +3 and higher value indicates higher discomfortable. Including metabolic factor, PMV did not actually consider an individuals' physiological response (IPR) such as heart rate, skin temperature, etc. To overcome PMV's limitation, IPR should be considered together with climatic factors when assessing pedestrians' thermal comfort. Therefore, we aim to develop a new function of thermal comfort by incorporating PMV and IPR, especially heart rate, with validation using personal perception of thermal comfort based on survey. We selected a route of 500m length in Suwon, South Korea and 9 volunteer pedestrians walked the selected route 8 times at 2-4 pm. The walk experiment was repeated for 4 days. During the experiment, air temperature, relative humidity, and wind velocity were monitored using portable meteorological sensors. The real-time heart rate of each pedestrian was recorded using wearable sensor (Mi-band3). After every day walk, we asked each pedestrian 10 questions regarding satisfaction of thermal environment, perceived temperature, etc. The average value of PMV was 2.99 belonging to very discomfort category. Although heart rate increased with the length of exposure time to heat, the heart rate over time did not consistently increase with air temperature. It was probably because our temperature range (31.9℃- 35.2℃) during the experiment was not large enough and heart rate was influenced by other factors such as wind velocity. In the survey, 50% of volunteer pedestrians responded 'discomfort' and the others answered 'slightly discomfort'. Comparing the survey (discomfort and slightly discomfort) with PMV (very discomfort), PMV generally overestimated. thermal comfort. We will categorize thermal comfort level according to heart rate increase between walking activity in outdoor and indoor. Here, the higher heart rate increase than average increase level indicates worse individual thermal comfort condition. This individual thermal comfort effect can modify the existing calculation of thermal comfort using air temperature, wind velocity, and humidity by adding modification factor of individual heart rate response (Ex. Thermal
comfort=weighting factor(0.189*air temperature-0.775*wind velocity+0.195*relative humidity)). The final thermal comfort will be calculated based on the function and examined the precision of function through comparative analysis with the personal thermal perception of survey. As heart rate is an individual variable, we expect our function can be a tool evaluating the personalized heat risk.