



## Outdoor human thermal perception in various climates: A review of the state of art for approaches, methods and quantifications

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Many research studies have been conducted in an attempt to define thermal conditions for humans in the outdoor environment and to grade thermal sensation. As a result, more than 170 of indices have been proposed. Consequently, examination of human thermal indices by thermal subjective perception has become recently a methodical issue to confirm the accuracy, applicability and validation of human thermal indices. The aims of this study are: (a) to review studies containing both calculated human thermal conditions and subjective thermal perception in the outdoor environment (b) to examine the relation between human thermal comfort range and outdoor thermal environment conditions for the most used human thermal indices (c) to compare between categories of thermal sensation of the most used indices for different climatic zones based on subjective perception and levels of thermal strain and (d) to update the state of art for human thermal investigation methods for indices quantifications.

A comprehensive literature review identified more than 120 peer-reviewed articles which investigated in-situ thermal conditions versus subjective thermal perception during 2001-2018. It seems that out of 170 human thermal indices that have been developed, only 4 (PET, PMV, UTCI, SET\*) are widely in use for outdoor thermal perception studies. Examination of the relation between human thermal comfort range and outdoor thermal environment conditions for selective indices in different climatic zones shows that the range of the thermal comfort or dis-comfort is affected by the outdoor thermal environment. For the PET index, the "neutral" range for hot climates of 24-26°C is agreed by 95% of the studies where for cold climate, the "neutral" range of 15-20°C is agreed by 89% of the studies. For the UTCI, the "no thermal stress" category is common to all climates. The "no stress category" of 16-23°C is agreed by 80% of the case studies, while 100% of the case studies agreed that the range is between 18-23°C.